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Does the U.S. Government Realize that the Sea is Rising? How to Restructure Federal Programs so that Wetlands and Beaches Survive

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ARTICLE

DOES THE U.S. GOVERNMENT REALIZE THAT THE SEA IS RISING? HOW TO RESTRUCTURE FEDERAL PROGRAMS SO THAT WETLANDS AND BEACHES SURVIVE

BY JAMES G. TITUS*

How far into the future does your responsibility extend? If our institutions are likely to protect the coastal environment for the next twenty to thirty years, but eliminate wetlands and beaches fifty to 200 years hence, do you say: "Not on my watch, not in my lifetime, not my problem." Do we have a duty to take actions that would lead future generations to look back at us and say, "at the turn of the millenium, people were thinking of us. They made mistakes, but given what they knew, they did the right thing, and we are better off because they did." Or is the future something that we discount by three percent per year so that the next century is worth a few cents on the dollar? Does our responsibility extend for as long as the greenhouse gases that we release today are likely to stay in the atmosphere? [1]

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[1] *See, e.g.,* WORKING GROUP 1, INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE, CLIMATE CHANGE 1995: THE SCIENCE OF CLIMATE CHANGE, 78, 84-85 (1996) (showing that even if emissions of carbon dioxide are cut in half, the atmospheric concentration

These questions are raised in an effort to examine whether we need to do something *now* to enable our coastal ecosystems to survive rising sea level on a sustainable basis. What we ought to do today depends as much on how we value the type of world we bequeath future generations, as it does on the various scientific and institutional questions that need to be resolved. Because of the difficulties involved in valuing the future, this article is limited to commenting on the science and our institutions. However, beneath this discussion of science and institutions lies the question, "how much does the future really matter?"

INTRODUCTION: ADAPTION TO THE GREENHOUSE EFFECT

Scientists throughout the world, as well as the U.S. Government, have concluded that emissions of carbon dioxide and other gases will warm the Earth 1.0-3.5 degrees Celsius in the next century.[2] Such a warming is most likely to raise sea level two feet per century for the next few hundred years,[3] but could raise the sea as much as fifteen feet by the year 2200.[4] Most of our existing beaches and about half our existing coastal wetlands could be eroded or inundated with even a two-foot rise.[5]

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of CO2 will double the pre-industrial concentration and remain at such an elevated level for at least the next 400 years) [hereinafter IPCC 1995].

[2] *See id.* at xi-xii (explaining that delegates from 96 countries approved the findings of the IPCC Scientific Assessment). *See also* EXECUTIVE OFFICE OF THE PRESIDENT OF THE UNITED STATES OF AMERICA, CLIMATE CHANGE: STATE OF KNOWLEDGE 1 (1996) (citing the IPCC results as the work of the "most comprehensive...assessment of climate change science ever produced... represent[ing] the work of more than 2,000 of the world's leading climate scientists.") (visited Apr. 5, 2000) <http://www.whitehouse.gov/Initiatives/Climate/background2.html>. *See, e.g.*, IPCC 1995 *supra* note 1, at 6.

[3] *See* IPCC 1995 *supra* note 1, at 6 (estimating that IPCC's best estimate is that global sea level will rise 49 cm from 1990-2100). *See also* JAMES G. TITUS & VIJAY K. NARAYANAN, U.S. ENVIRONMENTAL PROTECTION AGENCY, THE PROBABILITY OF SEA LEVEL RISE iii, 145-46 (1995) (explaining that along much of the U.S. coast sea level is likely to rise about 10 cm more than the global average) [hereinafter EPA 1995].

[4] *See* EPA 1995 *supra* note 3, at iii, 145-146.

[5] *See, e.g.*, James G. Titus et al., *Greenhouse Effect and Sea Level Rise: The Cost of Holding Back the Sea*, 19 COASTAL MANAGEMENT 172, 189-92, 200 (1991) (estimating that with a fifty centimeter rise in global sea level, twenty to forty percent of the coastal wetlands in the contiguous forty-eight states would be lost if currently developed shores are protected, and thirty-eight to sixty-one percent would be lost if all shores are protected) [hereinafter Titus, *Holding Back the Sea*]. *See also id.* at 178 (explaining that most recreational beaches are much narrower than the erosion that would occur from a one foot rise in sea level).

Seventy to ninety percent of our wetlands could be eliminated by a seven-foot rise.[6] Fortunately, most of these ecosystems can migrate inland as sea level rises and inundates lands that were formerly dry, but only if the adjacent dry land is undeveloped and property owners allow the sea to advance.[7] On the other hand, in areas where the adjacent dry land is developed and people use structures to hold back the sea, the wetlands and beaches will be eliminated.[8]

No one has undertaken a realistic assessment of the portion of our wetlands and beaches that will be able to migrate inland or the portion likely to be blocked by human activities. Currently, the federal regulatory programs to protect wetlands are doing little or nothing to increase the portion of our wetlands that are able to migrate inland.[9] Figure 2 illustrates the typical situation.[10] Wetlands and bay beaches are protected for the time being by programs that prohibit them from being filled. As a result, coastal construction is set back from the water's edge. As sea level rises and the shore erodes, however, property owners erect walls (called bulkheads) to protect their homes, which squeezes the wetlands and beaches between wall and water.

However, this two-step process of setting a house back and then building a bulkhead to protect it is a short-term solution because this approach fails to anticipate sea level rise. For all practical purposes, the federal coastal wetland protection policy says that as long as the wetlands we save are not filled on our watch, their probable elimination from bulkhead construction during future administrations is not our problem. The policy further states that current wetland loss due to sea level rise and bulkhead construction is not our problem as long as the

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[6] *See id.* at 200 (estimating that with a two-meter rise in sea level, sixty-six to ninety percent of U.S. coastal wetlands could be lost if all shores are protected).

[7] *See, e.g.*, JOHN & MILDRED TEAL, LIFE AND DEATH OF THE SALT MARSH 12 (1991) (describing landward advancement of wetlands as sea level).

[8] *See infra* Figure 1: EVOLUTION OF THE MARSH AS SEA LEVEL RISES.

[9] *See* discussion *infra* Part II.

[10] *See infra* Figure 2: THE TRANSITORY SUCCESS OF EXITING WETLAND PROGRAMS.

construction that made it inevitable happened during a previous administration.[11]

Current policies are a reasonable implementation of a policy that says, in effect, wetlands and beaches are important resources that must be preserved for the duration of this generation, but whether they survive for the next fifty to 200 years is not our problem. Recent efforts devoted to reducing greenhouse gas emissions suggest, however, that the Clinton Administration believes that, at least to some extent, we do have a responsibility to posterity.[12] Recent Administrations have only focused on the causes of global warming, but their rationale for reducing emissions has generally been the need to avert adverse effects, such as the impacts of sea level rise.[13] Given the President Clinton's willingness to commit resources to avoid the expected adverse effects of global warming by reducing CO_2 emissions, he ought to be equally willing to take other

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[11] *See* discussion *infra* Part II.

[12] *See, e.g.,* UNITED NATIONS FRAMEWORK CONVENTION ON CLIMATE CHANGE , KYOTO PROTOCOL, ART. 3.1 (last modified Apr. 5, 2000) <http://www.unfccc.org/resource/docs/convkp/kpeng.pdf> (requiring Annex 1 nations to limit emissions of greenhouse gases, on average, to five percent below the emissions during the year 1990). *See also id.* at Annex B (requiring a seven percent reduction in emissions from the United States). The United States signed the convention in 1998, but has yet to ratify it. *See* UNITED NATIONS FRAMEWORK CONVENTION ON CLIMATE CHANGE, KYOTO PROTOCOL STATUS OF RATIFICATION (last modified Apr. 5, 2000) <http://www.unfccc.org/ resource/kpstats.pdf>. REMARKS BY THE PRESIDENT, INTERNATIONAL CORAL REEF INITIATIVE EVENT (Nov. 22, 1996) (last modified Jan. 14, 2000) <http://www.epa.gov/globalwarming/news/ speeches/clinton_112296.html> ("If we work together [to reduce emissions of greenhouse gases] ... we can preserve our environment for our children, for their children, for generations beyond.").

[13] *See* WILLIAM JEFFERSON CLINTON, REMARKS BY THE PRESIDENT TO COMMUNITY MEMBERS ON CLIMATE CHANGE (May 4, 1998) (last modified Jan. 14, 2000) <http://www.epa.gov/ globalwarming/news/speeches/clinton_050498.html> (discussing a new program to cut greenhouse gas emissions from homes). *See also* WILLIAM JEFFERSON CLINTON, REMARKS BY THE PRESIDENT AT BIO-ENERGY CLIMATE CHANGE EVENT (Aug. 12, 1999) (last modified Jan. 14, 2000) <http://www.epa.gov/globalwarming/news/speeches/clinton_081299.html> (referring to bioenergy as a key way to meet the challenge of global warming). As of October 1, 1999, the EPA Global Warming Site provided full text for eighteen speeches by President Clinton and Vice President Gore related to the global warming issue. These speeches discuss measures to reduce greenhouse gas emissions, but fail to discuss measures to prepare for or adapt to the consequences of global warming. *See* U.S. EPA, SPEECHES AND PRESS RELEASES (last modified Jan. 14, 2000) <http://www.epa.gov/globalwarming/news/ speeches/index.html>.

types of measures to avoid these adverse effects, because they are often less expensive.

Alternative explanations have been presented regarding the lack of a strong policy to begin preparing for the consequences of global warming. At one end of the spectrum, some have suggested that efforts to prepare for global warming might undermine efforts to stop it by implying that we are accepting its inevitability.[14] At the other end of the spectrum, some people maintain that there is a group of government officials and environmentalists dedicated to energy efficiency, who simply oppose America's fossil fuel industry for a variety or reasons, including urban smog, issues relating to energy independence, and global warming.[15] Planning for the effects of global warming, so the thinking goes, is beside the point for people who are more worried about changing the way we use energy than the specific impacts of sea level rise and changing climate. Those explanations essentially imply that the federal government is likely to forsake cost-effective opportunities to prepare for and adapt to the consequences of global warming in the foreseeable future.

A less pessimistic explanation is that preparing for the consequences of global warming is everyone's second choice. Environmentalists recognize the need to adapt to global warming, but they feel that taking measures to head it off are more urgent. The fossil fuel industry favors preparing and adapting to the consequences of global warming, but maintains that it is

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[14] In 1984, for example, Florentine Krause of Friends of the Earth argued in FOE's publication *Not Man Apart*, that EPA was essentially throwing in the towel by advocating action to adapt to sea level rise and global warming. *See* Florentine Krause, FRIENDS OF THE EARTH, NOT MAN APART (1984) (citing Steve Seidel & Daniel Keyes, *Can We Delay a Greenhouse Warming*). *See also Letters*, J. AM. PLANNING ASSOC. (Dec. 1990) (complaining about James G. Titus, *Strategies for Adapting to the Greenhouse Effect*, J. AM. PLANNING ASSOC. 311-323 (Summer 1990)).

[15] *See, e.g.*, ENERGY STAR BUILDINGS AND GREEN LIGHTS PARTNERSHIP (last modified Apr. 6, 2000) <http://www.epa.gov/buildings/esbhome/> (EPA programs that promote energy conservation investments where the value of the energy saved more than pays for the costs of the lights and other equipment). *See also* WESTERN FUELS ASSOCIATION, COAL FIRED ELECTRICITY ENERGIZES THE U.S. ECONOMY, ANNUAL REPORT, 1999 (visited Apr. 7, 2000) <http://www.western-fuels.org/annual.htm> ("It is sad that the current regime seeks to marginalize [America's power plants, coal mines and railroads], such a large and important part of our society...by treating this great industry as a pariah.").

more urgent to stop some of the measures that the environmental community favors, such as global rationing of the use of fossil fuels.[16] Almost everyone would vote for adaptation and the research community regularly warns that it is necessary.[17] But in the polarized political climate associated with the global warming policy debate, none of the interest groups are stepping forward to push it thus far. Yet, if a centrist legislator or cabinet official were to push a practical set of adaptation options, they could be enacted with relatively little controversy—at least compared to the controversy likely to surround policies to reduce greenhouse gas emissions.[18]

This article examines practical federal options to prepare for one of the impacts of global warming—sea level rise. Part I examines the implications of greenhouse gases for our coastal zones, explains the causes and effects of sea level rise, and analyzes the implications of various responses. Part II examines how specific federal policies are currently failing to address existing and projected sea level rise, and enumerates a number of modest changes that may well have been included in these programs to begin with, had sea level rise been as well recognized when the programs were created as it is today. Addi-

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[16] *See, e.g., Hearings on the Status of the Global Climate Change Before the Subcomm. on Energy and Environment of the House Comm. on Science* (1997) (statement of Fred L. Smith, Jr., President, The Competitive Enterprise) (last modified Mar. 29, 2000) <http://www.house.gov/ science/smith_11-6.htm> (arguing against greenhouse gas emission limitations because a strategy of adaptation and resiliency would be more cost-effective).

[17] *See* NATIONAL ACADEMY OF SCIENCES, CHANGING CLIMATE 63 (1983) (recommending that planners of vulnerable resources take measures to prepare for climate change by factoring in possible shifts in the design of long-term systems). *See also* INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE, THE REGIONAL IMPACTS OF CLIMATE CHANGE: AN ASSESSMENT OF VULNERABILITY 7-8 (1998) (discussing the need for adapting to the effects of global warming).

[18] *Compare* WILLIAM JEFFERSON CLINTON, STATEMENT BY THE PRESIDENT (Dec. 10, 1997) (last modified Jan. 14, 2000) <http://www.epa.gov/oppeoee1/globalwarming/news/speeches/clinton_121097.html> (endorsing the Kyoto agreement to reduce CO2 emissions) *with* Jesse Helms, *Amend the ABM Treaty? No, Scrap It*, WALL ST. J., Jan. 22, 1999, at A10 (column by Senator Jesse Helms, Chair, Senate Foreign Relations Committee, demanding that the White House send the Kyoto Climate Treaty up for ratification, indicating that such an attempt would most likely fail) *and* Letter from Senator Jesse Helms to President William Clinton (Jan. 21, 1998) (last modified Jul. 23, 1998) <http://www.security-policy.org/papers/1998/98-P13at.html> (asking President Clinton to submit Kyoto treaty for ratification and warning him not to implement the treaty unless it is ratified).

tionally, this article explains the proposal that the National Wildlife Refuge program can be modified to address rising seas more easily than amending the federal wetland protection regulatory program, which currently deals with the problem.

I. THE GREENHOUSE EFFECT AND IMPLICATIONS OF RISING SEA LEVEL

Historically, carbon dioxide has only constituted about 0.03% of our atmosphere.[19] Yet, it plays a fundamental role for almost all life on our planet. Plants require CO_2 for photosynthesis, retaining the carbon and releasing free oxygen.[20] Animals eat the carbon-containing plants, breathe oxygen, and exhale carbon dioxide.[21] One of those animals, the human species, also remove the fossilized remains of prehistoric plants and animals from beneath the ground, burn those "fossil fuels," and thereby increase the level of CO_2 in the atmosphere.[22]

Throughout the twentieth century, scientists knew that if, hypothetically, the level of CO_2 rose from 0.3% to 0.6%, the earth would warm a few degrees by a mechanism known as the "greenhouse effect."[23] Nevertheless, until 1957, many scientists assumed that such an increase was unlikely because the oceans dissolve CO_2 and would thus be likely to keep the concentration in the atmosphere from increasing.[24] However, Roger Revelle and Hans Seuss demonstrated that the CO_2 does not dissolve as rapidly as had been assumed.[25] Monitoring stations were set

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[19] *See* IPCC 1995 *supra* note 1, at 78.

[20] *See* CO2 AND PLANTS: THE RESPONSE OF PLANTS TO RISING LEVELS OF ATMOSPHERIC CARBON DIOXIDE 23 (Edgar R. Lemon ed., 1983).

[21] *See* IPCC 1995 *supra* note 1, at 77 (Figure 2.1 illustrating the world's carbon cycle).

[22] *See id.* at 82.

[23] *See* JESSE H. AUSUBEL, NATIONAL ACADEMY OF SCIENCES, CHANGING CLIMATE 488 (1983) (Svante Arrehnius coined the term "greenhouse effect" at the turn of the 20th century).

[24] *See id* at 489-90 (Revelle and Seuss "pointed out for the first time that most of the CO_2 produced by the combustion of fossil fuels would stay in the atmosphere and would not be rapidly absorbed by the ocean.").

[25] *See id.*

up in Hawaii and Mauna Loa, resulting in a present consensus that CO_2 is increasing.[26]

There is no universal consensus of the precise impacts of increased CO_2. Since 1990, the Intergovernmental Panel on Climate Change (IPCC), a scientific agency established under the auspices of the United Nations, has issued periodic assessments of the scientific literature that attempts to represent the consensus of scientists with expertise in the issues related to the causes and effects of greenhouse gases.[27] A few climatologists always dissent from their findings.[28] According to the IPCC reports, greenhouse gases are almost certain to raise global temperatures 1.0-3.5 degrees Celsius in the next century.[29] The warmer temperatures are likely to raise sea level by melting mountain glaciers and expanding ocean water.[30] However, substantial uncertainties remain about changes in rainfall, droughts, hurricanes, and other factors relating to the climate of a particular region.[31] These regional uncertainties are great because existing global climate models are not yet accurate enough to project climate in particular areas.[32] Sea level rise is more certain than any other factors primarily because it is a global phenomenon. If more water is added to the oceans from the melting of glaciers, for example, the sea will rise everywhere.[33]

Projections of how much the sea will rise along the U.S. coast have been available since 1983 when EPA released a re-

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[26] *See id. See also* IPCC 1995 *supra* note 1, at 3.

[27] *See* IPCC 1995 *supra* note 1, at Forward.

[28] *See generally* Ross Gelbspan, *The Heat is On: The Warming of the World's Climate Sparks a Blaze of Denial*, HARPER'S MAGAZINE 82 (Dec. 1995) (discussing scientists skeptical about the IPCC projections of climate change).

[29] *See* IPCC 1995 *supra* note 1, at 5-6.

[30] *See id.* at 384.

[31] *See id.* at 44.

[32] *See id.*

[33] *But cf.* IPCC 1995 *supra* note 1, at 40-41 (pointing out that the rise is not precisely uniform). *See also* EPA 1995 *supra* note 3, at 144-45 (showing some variation among the projections of future sea level rise for various US locations).

port entitled *Projecting Sea Level Rise*.[34] EPA and IPCC both estimate that sea level is likely to rise about fifty centimeters in the next century.[35] When added to existing trends caused by other factors, sea level is likely to rise about two feet in the next century along most of the U.S. Atlantic and Gulf Coasts, and a few inches less along the Pacific Coast. Such a rise would be approximately double the rate of sea level rise experienced over the last century.[36] Both reports point out that the sea will keep rising at an accelerated rate for a few centuries.[37] Moreover, there is a small but important risk that the sea could rise three to four feet in the next 100 years and ten to fifteen feet in the next 200 years if, for example, the polar areas warmed two to three times the average warming and caused the Greenland Ice Sheet to melt or the West Antarctic Ice Sheet to slide into the ocean.[38]

A. EFFECTS OF SEA LEVEL RISE

Figures 4 and 5 *infra* illustrate key concepts for understanding the impact of sea level rise. Figure 4 illustrates the shore profile for Long Beach Island, New Jersey. The ocean tidal range is about five feet, with a sandy beach that is about forty feet wide at high tide and 140 feet wide at low tide.[39] The area between the high and low tide is called the intertidal zone, and in the case of a beach, the "wet beach." Behind the beach are the dunes, which are about thirty feet wide. The crest of the dunes are about fifteen feet above sea level. Behind the dunes are a row of houses, followed by a street parallel to the ocean. This street is about ten feet above sea level. The land elevations gradually decline as one moves landward, and about two-

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[34] *See generally* EPA 1995 *supra* note 3, at ch. 8.

[35] *See id.* at iii (estimating a 50 % chance the average global sea level will rise 45 centimeters). *See also* IPCC 1995 *supra* note 1, at 381 (Table 7.8 indicating that the best estimate rise by the year 2100 is 49 centimeters).

[36] *See infra* Figure 3: HISTORIC TRENDS IN SEA LEVEL 1990-97.

[37] *See* EPA 1995 *supra* note 3, at 127 (illustrating simulations that show sea level continuing to rise for three centuries). *See also* IPCC 1995 *supra* note 1, at 388 (illustrating simulations where sea level continues to rise for the next five hundred years).

[38] *See* EPA 1995 *supra* note 3, at iii.

[39] All of the facts listed in this paragraph are from personal observations by the author.

thirds of the island is only four to five feet above sea level. Landward of the island is Little Egg Harbor Bay. The Island protects the bay from the ocean, therefore the island is called a "barrier island" and the harbor is called a "back-barrier bay." The tide range along the bay is about two feet. The bayshore of the island was once mostly marsh, but people have erected bulkheads and now these bulkheads comprise most of the bay shore. In the bay, one finds various marsh islands. Along the mainland shore, the marsh is a few thousand feet wide in some places while in other areas, the shore has been developed.

Figure 5 shows a more general situation. Nationwide, some barrier islands are developed, while others are undeveloped either because they are part of a refuge or park, or because the costs of developing the island are prohibitive. The Coastal Barrier Resources Act placed many undeveloped barrier islands off limits for any forms of federal subsidies, including highways and flood insurance.[40] In some areas, the mainland is along the ocean, with no intervening barrier island. Along bays, some mainland shores are wetlands, and some are narrow sandy beaches. Some of the wetlands are part of a park or refuge, others border undeveloped land in private hands, while others border a developed area.

The most important effects of sea level rise are the gradual inundation of wetlands and low dryland erosion of beaches, increased flooding, and increases in the salinity of rivers, bays, aquifers, and wetlands.[41] For purposes of this article, the easiest way to grasp the impact of sea level rise is to simply consider the differences between the coastal and inland areas and imagine the coastal features moving inland.

Figure 6 *infra* illustrates the area vulnerable to inundation nationwide along the Atlantic and Gulf Coasts.[42] At that scale, one can tell that Louisiana, Florida, North Carolina, and Maryland have some large contiguous areas that are entirely below

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[40] *See* 16 U.S.C. § 3501(b) (1994).

[41] *See* Titus, *Holding Back the Sea supra* note 5, at 175. Saltwater intrusion is largely outside the scope of this article.

[42] This map of the United States illustrating 1.5- and 3.5-meter contours is from the Titus & Richman article to be published in "Climatic Research."

the five-foot contour. Table I provides the accompanying numerical estimates of the amounts of land below the five-foot contour, which suggests that all of the Gulf Coast states and the Atlantic coast states from New York southward have at least sixty square miles below the five-foot contour.[43] The land below the five- foot contour includes 705 square miles of developed barrier islands, 2000 square miles of farms, 2300 square miles of forests, 650 square miles of residential lands, and 400 square miles of urban and industrial areas.[44]

Figure 7 *infra* provides a blowup for the Chesapeake and Delaware Bay regions. The areas on that map below the five-foot contour include inhabited islands in the middle of Chesapeake Bay, most of Blackwater National Wildlife refuge in Dorchester County, Maryland, parts of West Ocean City, Maryland, and all of the tidal wetlands in Virginia, Maryland, Delaware, and New Jersey, with the possible exception of some of the high marsh along parts of Delaware Bay.[45]

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[43] *See infra* TABLE I: AMOUNTS OF LOW LAND IMPLIED BY VARIOUS MAP DATA SETS.

[44] *See infra* TABLE II: LAND COVER CLASSES FOR LANDS CLOSE TO SEA LEVEL (although we have been unable to obtain the necessary data, a large portion of this area is part of a national wildlife refuges or other federal land holding). *See also* Titus, *Holding Back the Sea supra* note 5, at 194-95 (discussing assumption that bayside areas below the five feet contour would have to be elevated as the sea rises). *See also id.* at 199 (reporting 705 square miles of "bayside" land that the study assumed would have to be elevated).

[45] *See, e.g.,* the printed 7.5-minute topographic maps published by the United States Geological Survey.

TABLE I: AMOUNTS OF LOW LAND IMPLIED BY VARIOUS MAP DATA SETS[46]

	0<Elevation<1.5 m			1.5m<Elevation<3.5m		
	Dem[1]	With[2]	With[3]	Dem[4]	With[5]	With
STATE	Only	NOAA	Edit	Only	NOAA	Edit
AL	60.9	75.2	—	148.1	136.9	—
CT	41.6	24.3	—	26.1	18.8	—
DC	0.5	2.6	0.6	0.9	0.9	1.5
DE	48.3	249.4	149.7	98.1	94.2	66.4
FL	2885.7	4729.3	4730.1	5002.5	4952.6	4920.1
GA	149.0	568.1	672.8	802.3	783.1	416.3
LA	1873.6	9546.3	—	1702.9	1677.7	—
MA	115.6	140.8	—	158.1	144.8	—
MD	140.8	1136.9	597.3	308.6	295.2	311.3
ME	113.3	147.8	—	111.8	68.0	—
MS	32.1	66.9	—	326.0	318.2	—

[46] James G. Titus & Charlie Richman, *Maps of Land Close to Sea Level, in* CLIMATE RESEARCH (forthcoming 2000) (on file with authors) [hereinafter, Titus & Richman].

NC	775.1	2356.3	2253.3	1530.3	1520.0	1492.1
NH	10.6	16.4	—	8.1	7.7	—
NJ	114.7	538.4	418.1	386.3	371.8	246.3
NY	97.3	224.5	92.6	70.1	58.9	102.6
PA	4.4	20.2	1.0	17.3	14.2	1.0
RI	56.9	47.1	—	26.3	23.8	—
SC	143.0	909.2	901.1	1001.2	991.7	927.3
TX	937.7	2022.1	1999.1	1710.6	1677.7	1626.7
VA	144.5	948.3	373.9	499.1	483.0	402.1
Totals	7745.5	23770.0	22254.4	13934.8	13639.0	12909.6

Definitions:

1. Area of land with an elevation of 1-meter according to the Digital Elevation Model.
2. Area of land that (a) is land according to the NOAA shoreline data, and (b) has an elevation of either 0 or 1 according to the DEM. Equal to (1) above, plus areas where DEM says 0 meters and NOAA says land (i.e. the area that the initial maps treated as land below the 50-cm contour), minus areas where NOAA says water and DEM says 1 meter.
3. The area of land within 1.5 meters of sea level, according final maps, developed by hand editing the initial draft maps based on the printed topographic maps.
4. Area of land with an elevation of either 2 or 3 meters according to the Digital Elevation Model.
5. Area of and between 1.5 and 3.5 meters above sea level according to the initial draft maps; that is, the portion of land described in (4) above that NOAA calls land.

TABLE II: LAND COVER CLASSES FOR LANDS CLOSE TO SEA LEVEL[47]

LAND BELOW THE 1.5 METER CONTOUR (SQUARE MILES)

State	Total	Residential	Urban/ Industrial	Agriculture	Forest	Wetlands	Missing Data
AL	75.1	7.0	4.2	1.4	11.9	48.4	2.3
CT	24.3	5.1	3.7	0.4	5.0	10.0	0.1
DC	0.6	0.0	0.5	0.0	0.0	0.1	0.0
DE	149.5	3.4	0.6	27.9	10.5	107.0	0.0
FL	4506.1	185.0	100.9	128.3	630.2	3447.8	14.0
GA	668.9	13.4	6.9	6.0	68.6	573.0	1.1
LA	9512.4	156.9	128.7	1153.4	339.8	7705.7	27.9
MA	140.3	23.3	16.8	3.4	23.6	69.0	4.3
MD	552.5	17.1	2.4	94.0	133.4	305.5	0.0
ME	147.5	19.2	7.4	8.9	67.6	43.3	1.2
MS	66.8	4.2	2.4	0.0	3.3	55.2	1.7
NC	2128.3	51.3	27.2	235.6	464.9	1346.2	3.1
NH	16.3	2.9	1.8	1.8	3.7	5.8	0.2
NJ	417.2	43.4	17.7	33.8	20.5	299.8	2.0
NY	92.3	26.7	13.3	2.7	6.7	42.5	0.4
RI	47.1	13.5	9.8	5.4	9.0	9.2	0.2
SC	899.2	18.0	11.4	72.5	97.5	698.5	1.2
TX	1990.7	48.3	58.6	282.4	381.9	1214.5	4.9
VA	127.7	15.6	10.0	12.7	25.4	64.0	0.0
Total	21562.9	654.1	424.5	2070.8	2303.5	16045.4	64.7

[47] Email from Charlie Richman & Kim Balassiano to James G. Titus (on file with author) (this table represents an overlay of the Managed Lands Data Base of The Nature Conservancy with the Elevation Data Base created in Titus & Richman *supra* note 46) [hereinafter Richman & Balassiano email].

LAND BETWEEN THE 1.5- AND 3.5- METER CONTOURS (SQUARE MILES)

State	Total	Residen-tial	Urban/ Industrial	Agriculture	Forests	Wetlands	Missing Data
AL	136.9	20.5	14.4	8.6	53.8	38.2	1.5
CT	18.8	6.3	3.6	0.7	2.0	6.2	0.1
DC	1.5	0.0	1.3	0.0	0.1	0.1	0.0
DE	66.2	5.9	1.4	29.8	13.2	15.9	0.0
FL	4488.1	480.5	247.7	431.9	1454.3	1868.9	4.9
GA	415.9	20.5	13.5	14.4	204.3	163.2	0.1
LA	1672.2	83.9	48.9	891.2	315.0	332.9	0.3
MA	144.2	35.7	12.9	4.9	53.0	37.1	0.6
MD	308.5	22.0	7.6	117.9	111.2	49.8	0.0
ME	68.0	10.8	4.4	4.7	37.2	10.8	0.2
MS	318.1	27.8	10.1	15.1	135.3	129.6	0.2
NC	1467.3	55.9	18.0	448.5	504.9	439.3	0.7
NH	7.7	1.2	1.0	1.0	2.5	2.1	0.0
NJ	245.7	47.3	32.6	16.5	52.7	96.0	0.6
NY	102.3	48.6	23.3	5.0	6.0	19.2	0.2
RI	23.8	7.4	5.2	3.3	5.4	2.6	0.0
SC	925.3	29.7	23.1	149.4	352.4	370.5	0.1
TX	1623.2	49.4	49.9	570.4	729.9	222.2	1.5
VA	294.0	52.0	26.2	80.6	80.5	54.7	0.0
Totals	12327.9	1005.3	544.9	2793.9	4113.5	3859.2	11.0

Although the five-foot contours provide an indication of the land vulnerable to sea level rise, for several reasons they do not depict where the shore would be if the sea rose five feet. Some coastal wetlands are able to grow upward as the sea rises by trapping sediment and forming peat, so many areas below the five-foot contour might still be wetland if the sea rose five feet.[48] On the other hand, the five-foot contour is only three feet above mean high water in the typical area with a three-foot tidal range. The sea has already risen six inches since 1929 when the benchmark for the contours was established, and mean high water is eighteen inches above mean sea level in such an area.[49] A study by EPA that considered all of these factors estimated that without human intervention, a one-meter rise in sea level would inundate 7700 square miles of dry land, of which 2600 square miles would be converted to wetlands with the remainder to open water.[50] The creation of 2600 square miles of new wetlands would partly offset the inundation of 8700 square miles of existing wetlands, for a net loss of about 6000 square miles.[51] Currently, about 19,500 square miles of dry land are vulnerable to occasional coastal flooding. If the sea rises three feet, the floodplain would expand to 26,000 square miles.[52] Additionally, all of the existing floodplain would experience another three feet of flooding.

A more immediate concern in many areas is coastal erosion. In addition to the direct inundation of low land, higher sea

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[48] *See* Richard A. Park et al., *The Effects of Sea Level Rise on U.S. Coastal Wetlands*, *in* THE POTENTIAL EFFECTS OF GLOBAL CLIMATE CHANGE ON THE UNITED STATES app. B at 1-7, 1-19 (Joel Smith & Dennis A. Tirpak eds., 1989) (discussing wetland accretion and listing accretion rates at 46 coastal sites dispersed throughout the contiguous United States) [hereinafter Smith & Tirpak].

[49] *See* James G. Titus & Michael Greene, *An Overview of the Nationwide Impacts of Sea Level Rise, in* Smith & Tirpak *supra* note 48, at app. B 5-10, n. 8 (explaining why the five-foot contour was only about four and one half feet above mean sea level) [hereinafter Titus & Greene].

[50] *See id.* at 5-27.

[51] *See id.* at 5-26 (reporting estimate that if all shores are protected, a one-meter rise in sea level implies a loss of 8673 square miles of wetlands, whereas if no shores are protected, the net loss is only 6046).

[52] *See generally* FEDERAL EMERGENCY MANAGEMENT AGENCY (FEMA), FEDERAL INSURANCE ADMINISTRATION, PROJECTED IMPACT OF RELATIVE SEA LEVEL RISE ON THE NATIONAL FLOOD INSURANCE PROGRAM (1991).

level can cause land above sea level to erode approximately fifty to 200 feet for every foot of sea level rise.[53] Coastal geologists generally point out that beach erosion does not, by itself, reduce the size of a beach. Rather, the beach system simply migrates inland.[54] Barrier islands are a special case. As sea level rises, some have disintegrated and disappeared.[55] Other islands, however, have migrated landward through the "overwash" process, by which storms push sand onto the bay sides of the islands as the ocean sides erode.[56] The overwash process allows the islands to survive even though their seaward boundaries are eroding.[57] This process is sometimes called "barrier island migration."[58]

B. RESPONSES TO SEA LEVEL RISE

1. Generic Responses

There are two primary responses to sea level rise: holding back the sea or allowing the shore to retreat. The two fundamental ways for holding back the sea are constructing walls and elevating land surfaces. Structures such as dikes, seawalls, bulkheads, and revetments form a barrier between water and land. They eventually eliminate the intervening beach, wetlands, and other intertidal zones, but leave the dry land relatively unaffected. Elevating land surfaces can allow wetlands and beaches to survive.[59] Along the ocean coast, most

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[53] *See* Titus, *Holding Back the Sea supra* note 5, at 178 (citing studies of erosion caused by sea level rise).

[54] *See* Orrin H. Pilkey et al., LIVING WITH THE EAST FLORIDA SHORE 52 (1984) (beach erosion by itself does not mean that a barrier island is disappearing. The Bruun Rule of Erosion holds that the entire beach profile simply shifts inland as the sea rises, with the dimensions of the beach remaining unchanged) [hereinafter Pilkey].

[55] *See* MARINE BOARD, NATIONAL RESEARCH COUNCIL, RESPONDING TO CHANGES IN SEA LEVEL 44 (1987) (explaining that the Chandeleur Islands and Isles Dernieres barrier chains will be lost during the next 100 years with current trends in relative sea level) [hereinafter Marine Board, *Responding to Changes in Sea Level*].

[56] *See* Pilkey *supra* note 54, at 21(explaining overwash).

[57] *See id.* at 14-23 (explaining and illustrating the landward migration of barrier islands as sea level rises).

[58] *See id.* at 16-18.

[59] *See* Titus, *Holding Back the Sea supra* note 5, at 179-84 (explaining why study assumed that sheltered shores would be protected with walls while beach resorts would be protected with sand replenishment).

states have programs to place additional sand onto their ocean beaches to counteract the erosion.[60] Along bays, however, only Delaware, Mississippi, and New Jersey regularly nourish even some of the beaches.[61] In most states, people simply armor the bay shore with a bulkhead or rock revetment.[62]

In most cases, retreat simply means abandoning vulnerable areas to the sea. As a result, this option is often very unpopular with coastal governments and economic interests. In the case of barrier islands, retreat might be more politically palatable if it was coupled with the creation of new land by filling the bay side as the ocean side erodes. Such a response would essentially imitate the natural "overwash" process by which undeveloped barrier islands migrate landward as sea level rises. An example of this is demonstrated in Figure 7 *infra*. Regardless of whether new land is being created, retreat can be implemented by deliberately moving structures back in anticipation of erosion, not building in areas likely to erode, or by simply not rebuilding if a storm destroys a structure. Land-use planning measures, rather than technology, tends to be the primary tool of governments attempting to facilitate a retreat.

Governmental policies for ensuring that human activities do not impede the natural inland migration generally fall into two categories: prevent development,[63] or otherwise decrease the property owner's economic motivation to hold back the sea, or

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[60] *See* U.S. ARMY CORPS OF ENGINEERS, SHORELINE PROTECTION AND BEACH EROSION CONTROL STUDY 6, 42-46 (1994) (stating that beach nourishment has attained broad acceptance as a substitute for fixed structures and listing three-fourths of the states as employing beach nourishment) [hereinafter Shoreline Protection and Beach Erosion Study 1994]. *See also infra* Table 3: SHORELINE ARMORING AND BEACH NOURISHMENT POLICIES OF VARIOUS STATES.

[61] *See* James G. Titus, *Rising Seas, Coastal Erosion, and the Takings Clause*, 57 MD. L. REV. 1249, 1301-1302, n. 80 (discussing Mississippi Bay Beaches) [hereinafter Titus, *Rising Seas*].

[62] *See id.* (listing estimates by state officials of the extent of shoreline armoring along various states).

[63] Denial of governmental subsidies such as infrastructure, flood insurance, mortgage insurance, and the income tax deduction for mortgage interest payments could discourage development, but would not necessarily prevent it. *See* U.S. OFFICE OF TECHNOLOGY ASSESSMENT, PREPARING FOR AN UNCERTAIN CLIMATE 199-204 (1993) [hereinafter OTA].

rolling easements,[64] which are policies that allow development, but explicitly prevent property owners from holding back the sea. Each of these policies can in turn be subdivided according to whether the government or the property owner absorbs the loss.

2. Preventing development

Policy makers have two ways to decrease a property owner's motivation to erect a bulkhead: increase the cost or decrease the benefit of erecting such a structure. Perhaps the most important way by which governments have increased the cost to property owners of these structures has been the gradual curtailments of subsidies for their construction.[65] Removing subsidies for development can also decrease the incentive to undertake construction that might later require protection.[66] On the other hand, subsidized beach nourishment has decreased the need to build seawalls along ocean shores and would presumably have the same effect if it were applied along estuarine

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[64] Several different terms have been used to describe this idea. *See generally Greenhouse Effect, Sea Level Rise, and Coastal Zone Management*, 14 COASTAL ZONE MANAGEMENT J. [now COASTAL MANAGEMENT] 166 (1986) (using the phrase "in effect, buy an option"). *See also* REPORT TO CONGRESS, *The Global Climatic Change on the United States* B-5-51 ("presumed mobility") (on file with author); *Greenhouse Wetland Policy*, *in* GREENHOUSE EFFECT, SEA LEVEL RISE, AND COASTAL WETLANDS 44-54 (James G. Titus ed., 1987) ("presumed mobility"); *See also* Titus, *Holding Back the Sea supra* note 5, at 182 and Figure 6 *infra* (calling for enforcement of the public trust doctrine). *See generally id.* at 192 ("the Maine Approach"); *See also* Lisa A. St. Amand, *Sea Level Rise and Coastal Wetlands: Opportunities for a Peaceful Migration*, 19 B.C. ENVTL. AFF. L.REV. 1, 3 (1991) ("presumed mobility"). During the 1980s, this author started pushing the idea based on finance theory and searched in vain for a reasonably descriptive term. Later, it became evident that the coastal laws in some states had—for different reasons—arrived at the same result and that the courts in Texas had settled upon a particularly useful term, "rolling easement." Therefore, federal documents discussing responses to sea level rise since 1994 have used the term rolling easement.

[65] Until the early 1990s, for example, Maryland offered interest-free loans to anyone who built a bulkhead or revetment to control erosion. Today, the state subsidy only applies to projects that rely on planting vegetation. Telephone Interview with Rick Ayella, Maryland Department of the Environment (Oct. 10, 1996).

[66] The Coastal Barrier Resources Act, 16 U.S.C. § 3501-3510 (1985) (this statute curtails federal expenditures for infrastructure and flood insurance for designated coastal areas). Until it was repealed, the Upton-Jones Amendments of the National Flood Insurance Program denied federal flood insurance to homes that are about to collapse into the sea due to erosion, and authorized subsidies for the removal of these homes to other locations. *See* 42 U.S.C. § 4013(c)(2)(B) (repealed 1994).

shores. [67] Nevertheless, these measures are unlikely to substantially reduce the nationwide rate of bulkhead construction along estuarine shores. Even without subsidies, riparian owners in many areas continue to erect bulkheads and no state is considering a comprehensive program of beach nourishment along estuarine shores.[68]

Policies that prevent development largely eliminate the benefits of building a bulkhead, and hence, are likely to conserve natural shorelines in a wider variety of situations.[69] The most common way to prevent development in vulnerable areas is to require a "setback," which prohibits construction seaward of a setback line.[70] Setbacks can be based on elevation, erosion rates, or estimates of how the shore might change in the future. Land subdivision policies requiring deeper lots along the shore can help to ensure that setbacks do not leave shorefront owners without a permissible building site. Building codes can require houses to be designed to be moveable or limit their size.[71]

Policies that prevent development in areas vulnerable to erosion have generally been implemented through regulations that do not compensate landowners.[72] At least conceptually, the mechanics of such policies would essentially be the same if the government compensated property owners by purchasing

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[67] *See* Shoreline Protection and Beach Erosion Study 1994 *supra* note 60, at 24, 37-46 (providing data on 56 federal funded beach nourishment projects).

[68] *See infra* TABLE III: SHORELINE ARMORING AND BEACH NOURISHMENT POLICIES OF VARIOUS STATES.

[69] The lack of development greatly reduces the value of protecting lands with erosion control structures. In some states, regulations also prohibit bulkheads that protect land but no structures. *See* e.g., TABLE III *supra* note 68.

[70] *See, e.g.*, OTA *supra* note 63, at 187 (listing 15 states and territories that have implemented setbacks).

[71] *See* MAINE STATE PLANNING OFFICE, ANTICIPATORY PLANNING FOR SEA LEVEL RISE ALONG THE COAST OF MAINE 5-8 - 5-9 (1994) (explaining that Maine's regulations discourage the construction of large buildings in areas that will be affected by beach processes with a three-foot rise in sea level, but do not prevent construction of small structures "based on the assumption that the smaller structures are moveable and would be moved if threatened by coastal erosion.").

[72] Setbacks have often been challenged as takings without compensation. *See* Titus, *Rising Seas supra* note 61, at 1334-39 (discussing the successful challenge of the South Carolina setback).

non-development easements.[73] Alternatively, a public or private entity can purchase a property outright.[74]

3. Rolling easements

A more narrowly tailored way to ensure that natural shorelines survive rising sea level is to simply create a rule to guarantee this result. The term "rolling easement" is borrowed[75] from the common law of Texas[76] to describe a broad collection of arrangements under which human activities are required to yield the right of way to naturally migrating shorelines. Rolling easements can be implemented by eminent domain purchases of options, easements, covenants, or defeasible estates that transfer title if a bulkhead is built or the sea rises a certain amount, or with statutes that accomplish the same result.[77]

The simplest way to implement rolling easements throughout a state would be to prohibit bulkheads or any other structures that interfere with naturally migrating shores.[78] Another

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[73] Such easements could be purchased either with cash or transferable development rights, meaning the right to develop other properties more intensely than would otherwise be the case.

[74] For example, New Jersey's Blue Acres program purchases property that is vulnerable to erosion along the ocean. *See* STATE OF NEW JERSEY, DEPARTMENT OF ENVIRONMENTAL PROTECTION, GREEN ACRES PROGRAM (last visited Apr. 9, 2000) <http://www.state.nj.us/dep/greencres/blue.htm> (explaining the Blue Acres program).

[75] *See* Titus, *Rising Seas supra* note 61, at 1313.

[76] *See* Feinman v. State, 717 S.W.2d 106, 111 (Tex. Ct. App. 1986) (recognizing the beach as a rolling easement because otherwise the area of public access would disappear as the shore erodes). *See also* Matcha v. Mattox, 711 S.W.2d 95, 100 (Tex. Ct. App. 1986) ("[B]ecause legal title shifts with the natural movements of the beach, this Court has concluded that the public easement also shifts with the natural movements of the beach.").

[77] *See* Arrington v. Mattox, 767 S.W.2d 957, 958 (Tex. Ct. App. 1989) (holding that the statute requiring removal of structures seaward of the vegetation line merely enforced a common law public right, and hence was not a legislative taking). *See also Matcha*, 711 S.W.2d at 99-101 (holding that as the vegetation line moves inland, the State can enjoin reconstruction of a storm-damaged house that is left seaward of the vegetation line).

[78] *See, e.g.*, Rhode Island Coastal Resource Management Program § 210(B)(4) (1993) ("Bulkheading and filling along the inland perimeter of a marsh prevents inland migration of wetland vegetation as sea level rises."). *See also id.* § 210.3(C)(3) ("In Type 1 waters, structural shoreline protection may be permitted only when the primary purpose is to enhance the site as a conservation area and/or a natural buffer against storms.").

approach is for the government to purchase a property right to take possession of privately owned land whenever the sea rises by a particular amount.[79] Alternatively, the deed to the property interest could specify that the boundary between publicly owned tidelands and the privately owned dryland will migrate inland to the natural high water mark, whether or not human activities artificially prevent the water from intruding. A government could also obtain a rolling easement by passing a statute that simply "clarified" existing property law by stating that all coastal land is subject to a rolling easement.[80] Such a clarification would not be a usurpation of private property because the Public Trust Doctrine and the Law of Erosion have long held that the intertidal zone should remain in public hands and that property lines migrate as the shore erodes.[81]

Recognizing that the mechanics of rolling easements would vary, Figure 8 *infra* illustrates a prototype rolling easement along a wetland shore.[82] Under such a regime, bulkheads and any filling of privately owned land are prohibited except to the extent necessary to keep the property useful (e.g. to build a driveway). No one need abandon a house if it is safe and on private property, even as the marsh takes it over. The first significant impact of a rolling easement might be the knowledge that the land may *eventually* have to be abandoned would lead an owner to avoid major capital expenditures to expand or otherwise upgrade the house.[83] Later, this expectation leads the owner to avoid major repairs (such as replacing roofs) in favor of stop-gap measures (such as repairing leaky roofs).

The sea eventually rises enough to severely flood the yard whenever an extremely high tide occurs. Without the rolling

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[79] Such an interest might be characterized as the government taking an executory interest, or perhaps, because the King was the original owner of the land, as an impliedly reserved possibility of reverter. *See* Titus, *Rising Seas supra* note 61, at 1378-82.

[80] Texas law now explicitly states that houses must be torn down as the shore approaches. *See* TEX. NAT. RES. CODE ANN. § 61.011 (West Supp. 1997).

[81] *See* Titus, *Rising Seas supra* note 61, at 1361-71.

[82] *See id.* at 1292-97. This variation would occur because the rights of coastal property owners vary and because there are many ways by which rolling easements might be implemented.

[83] *See id.* at Figure 4.

easement, the homeowner might use fill to elevate the back yard, and possibly install a bulkhead as well. A rolling easement prevents these shore protection options, which would impair the ability of wetlands to migrate inland. To keep the property useful, the homeowner is allowed to haul in gravel or otherwise elevate the driveway. When the sea rises enough for spring high tide to flood much of the yard, high marsh vegetation takes over, but the property is still privately owned.[84] Assuming that the house is on pilings or otherwise elevated, it continues to be useful. Finally, enough of the property is inundated by mean high tide for the house to be on public land.[85] The homeowner is free to move the house and clean up the site.

The situation would be similar along estuarine beaches and relatively large bodies of water, where property is more likely to be lost to erosion than to a gradual inundation and conversion to marsh. As with the wetland prototype, the existence of the rolling easement would discourage reinvestment as the shore approaches. The primary restriction of the rolling easement would be the prohibition of bulkheads. Fill is less of an issue because these shores are often well above sea level.[86] As the shore erodes, eventually the house will be, at least partly, on the public beach. If access along the shore is extremely important, the owner could be required to move the house at that point.

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[84] *See* Kana, et al., *Charleston Case Study, in* GREENHOUSE EFFECT, SEA LEVEL RISE, AND COASTAL WETLANDS 39-40 (James G. Titus ed., 1987) (reporting that high marsh is found in those areas that are above mean high water but below mean spring water). *See id.* at 48-51 (showing how wetland zonation could migrate inland in Charleston area as sea level rises).

[85] In Maine, Massachusetts, Pennsylvania, Delaware and Virginia, where the public only owns up to mean low water, ownership does not shift until the sea rises enough for the house to be inundated at low tide. *See* David C. Slade et al., *Lands, Waters and Living Resources Subject to the Public Trust, in* PUTTING THE PUBLIC TRUST DOCTRINE TO WORK 69 n. 22, 70 n. 23 (1990).

[86] As a result, property owners might be allowed to hold back the sea with beach nourishment. Along wetland shores, elevating the land with fill—even without a bulkhead—prevents new areas from being flooded and new marsh from forming inland as sea level rises. Elevating land causes a net loss of wetlands unless the marshes are elevated as well (which never happens). By contrast, along sandy beaches, the beach will tend toward a characteristic shape and return to that shape even if it is disrupted through the addition of sandy material or rising sea level. *See* Marine Board, *Responding to Changes in Sea Level supra* note 55, at 75-76.

D. CHOOSING WHETHER OR NOT TO HOLD BACK THE SEA

When discussing responses to sea level rise, the term "protection" refers to protecting coastal property, not the environment. The "no-protection" approach is most likely to preserve the natural environment in most cases. In undeveloped areas, the wetlands and beaches will simply migrate inland as sea level rises. Even in developed areas, if a policy of retreat ("no-protection") is implemented, structures near the shore can be removed and thus, the wetlands and beaches will be able to migrate inland as if the area had been undeveloped.[87] For this to happen, however, some people with property along the shore would have to give up land to the sea and relocate their structures. If the sea is held back with dikes and bulkheads, however, land would not be lost to the sea and structures would not have to be relocated but, the wetlands and beaches would be eliminated as the water approaches the walls. In addition to the loss of habitat, access along the water for landing boats, recreation, and fishing would be diminished, and in some cases, the dikes would impair the view of the water.[88]

Thus, the choice whether or not to hold back the sea may force policy makers to decide which is most important: protecting development or maintaining the environmental and amenity values from retaining natural shores. The third option of elevating land surfaces may, in some cases, allow policy makers to avoid that choice and save both property and the natural shore.

By periodically pumping sand onto beaches, a community can stop the shore from eroding *and* continue to have a beach. It is also possible to elevate wetlands by enhancing the natural accretion process or, if that fails, simply rebuild the wetlands in locations where they have been lost. However, the technology for doing this is in its infancy. Elevating wetlands tends to be expensive, because houses and dry land surfaces also have to be elevated to prevent inundation. Additionally, if the goal

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[87] Nevertheless, a large rise in sea level would still probably decrease the total area of coastal wetlands by narrowing the band of wetlands. *See, e.g.,* Figure 1 *infra* EVOLUTION OF THE MARSH AS SEA LEVEL RISES.

[88] *See* Titus, *Rising Seas supra* note 61, at 1361-68.

were to completely preserve the status quo, it would also be necessary to elevate the bottoms of shallow bays to prevent the water from becoming deeper.

If applied uniformly throughout the nation, retreat, armoring the shore, or raising land surface elevations would each be expensive. Considering only the development through the 1980s, economist Gary Yohe estimated that $165-451 billion would be lost from a one-meter rise in sea level if no shores were protected. [89] At the same time, EPA researchers estimated that a strategy of beach nourishment and elevating land surfaces along the ocean, and protecting lands that were currently developed along bay shores with dikes, would cost a total of $143-305 billion excluding the value of lost land.[90] The actual cost would probably be less because no single approach would be appropriate nationwide. For example, New York City will not be abandoned to the sea, and undeveloped areas are most likely not going to be armored. A more recent study by Yohe estimated that the cost would be only forty-five billion dollars under a scenario in which areas are protected if and only if the value of the land and structures being protected is sufficient to justify the protection.[91]

1. Likely Outcomes from Current Policies

Most of the key differences between how we manage our ocean and bay shores appear to imply that if current policies continue, natural shores are likely to survive along the ocean

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[89] *See* Gary Yohe, *The Cost of Not Holding Back the Sea*, 18 COASTAL MANAGEMENT 403-432 (1990) (estimating the value of land and structures that existed at the time of the study in the area likely to be lost from a 50, 100, or 200 centimeters rise in global sea level).

[90] *See* Titus, *Holding Back the Sea supra* note 5, at Table 9.

[91] *See* Gary Yohe et al., *The Economic Cost of Greenhouse-Induced Sea-Level Rise for Developed Property in the United States*, 32 CLIMATIC CHANGE 387, 392, 403-5 (1996) [hereinafter Yohe, *Economic Cost*]. The study also quantified the extent to which the cost to property owners from eroding shores could be reduced if, decades before their property was threatened, owners understood the need to abandon the shore. *See id.* at 390-92. The study estimated that with no foresight, the nationwide cost of a one-meter rise in sea level would be $45.4 billion, but with pure foresight, it would be only $36.1 billion. *See id.* at 403-5. The nationwide figures, however, include the cost of beach nourishment and other measures for holding back the sea. *See id.* at 392-93, 405. In several of the sites where holding back the sea is unlikely, the certainty of knowing what would happen to the shore would decrease the cost of sea level rise by 50% to 75%. *See id.* at 397-98.

coast but gradually be eliminated along bay shores. Table 3 *infra* summarizes the shore protection policies for the coastal states, showing that most states allow armoring along bays but either prohibit it along the ocean or have strong ocean-beach nourishment programs that make it unnecessary. There are several reasons why shoreline armoring is more common along bays than along oceans.[92] First, a seawall strong enough to hold back the ocean can cost ten times as much as the bulkhead necessary to stop a bayshore from eroding.[93] A private property owner may find it difficult to justify spending $150,000 on a seawall in front of her home, while a $15,000 bulkhead or revetment along the bay would be worthwhile. Second, there is a strong public demand for the use of ocean beaches and hence any structure that eliminated the beach would be opposed by the public. Along bay shores, the primary demand for access to the shore tends to be access to the bay itself, not the beach (for example, for boat launching).[94] Third, existing state coastal zone policies in several states prohibit shoreline armoring along the ocean, but not the bay.[95] Fourth, beach nourishment is currently employed along the ocean in many states, but only along a few bays. Finally, existing policies designed to protect ocean beaches, mostly at the state level, consider the dynamics of migrating shores, while the federal regulatory program to protect wetlands ignores the implications of sea level rise.

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[92] For purposes of this discussion, the term "ocean shore" includes the Gulf of Mexico and Gulf of Maine, as well as Connecticut's shores along Long Island Sound. The term "bay" includes tidal rivers, small sounds, and estuaries.

[93] *Compare* Robert M. Sorensen et al., Control of Erosion, Inundation and Salinity Intrusion Caused by Sea Level Rise, in GREENHOUSE EFFECT AND SEA LEVEL RISE *supra* note 84, at 179, 188 (noting that seawalls used along shores with large waves can cost $3000 per foot or more) *with id.* at 191-92, 195-97 (stating that bulkheads and revetments used along inland waters cost about $125-$300 per foot). Bulkheads are vertical structures that are usually made of wood that can stop erosion in calm waters but not in the face of substantial waves. *See id.* at 195-97. Revetments are sloped structures generally made of rock that can withstand greater wave forces. *See id.* at 191-92. Seawalls are vertical walls that can withstand ocean waves. *See id.* at 195.

[94] *See* Titus, *Rising Seas supra* note 61, at 1294 n. 49 (citing officials in Maryland as focussing on the need for boat launching facilities).

[95] *See infra* TABLE III.

TABLE III: SHORELINE ARMORING AND BEACH NOURISHMENT POLICIES OF VARIOUS STATES

	Armoring Ocean Beach		Armoring Bay Beach	
	Allowed?	Nourishment?	Allowed?	Nourishment?
Maine[i]	No	Rare	No	No
NH[ii]	Yes	Yes	Yes	No
MA[iii]	Yes	Large bays		
MA Dunes[iv]	No	No		
MA Banks[v]	Pre-1978	Pre-1978		
RI [vi]	Urban-No	Yes	If needed	Under Consideration
CT[vii]	If needed	Yes	If needed	No
NY[viii]	Possible	Yes	Yes	Occasional
NJ[ix]	Yes	Yes	Yes	Occasional
DE[x]	Rare	Yes	Occasional	Yes
MD	No longer	Yes	Revetments (Rare)	Bulkheads (No)
VA[xi]	Yes	Yes	Yes	Yes
NC[xii]	No	Yes	Yes	Rare
SC[xiii]	No	Yes	Yes	No
GA[xiv]	If needed	Yes	Yes	No
FL[xv]	Possible	Yes	Revetments	No
AL[xvi]	Yes	Yes	Yes	No
MS[xvii]	No	Yes	Yes	Yes
LA[xviii]	Yes	Yes	Yes	No
TX[xix]	No	Yes	Yes	Occasional
CA[xx]	Yes	Yes	Yes	Rare
OR[xxi]	Pre-1978 (if needed, No Post-1978)	No	If public benefits	No
WA[xxii]	Occasional	No	Pre-1992	Small projects
AK[xxiii]	Yes	No	Yes	No

HA[xxiv]	Yes	Yes	Yes	No

Editor's note: Comprehensive footnotes for Table III are found at the end of the article.

The net results of all these factors is that under current trends, our ocean beaches seem likely to survive, but our bay beaches will be eliminated, and over time our coastal wetlands may gradually dwindle. Currently, the only exceptions are Maine, Rhode Island, and at least parts of Massachusetts, all of which have explicitly considered the possibility that sea level rise could squeeze ecosystems, and have responded with regulations designed to enable wetlands to migrate inland as the sea rises.[96]

This is not to say that all wetlands will be eliminated. The one key difference between ocean and bay that favors retaining bay shores is the fact that much of our bayfront lands are still farms and forests. Figure 9 *infra* illustrates a likely outcome. The developed barrier island is simply raised in place, while the undeveloped island narrows and migrates landward. The wetlands in front of the development are lost, as are some of the wetlands in front of the farm as a result of subsequent development. The remaining farmland, as well as the wildlife refuge, is inundated allowing new wetlands to form. Moreover, the tidal wetlands replace the freshwater nontidal wetlands in the generic swamp. Even if sea level rises too rapidly for wetlands to keep pace through vertical accretion, the higher water levels are unlikely to eliminate all wetlands, just a large fraction.

2. *Do We Need to Change Our Policies?*

Would the net loss of wetlands be too great if sea level rises more than one meter and existing policies continue? That question has never been formally addressed by the studies that have analyzed wetland loss due to sea level rise. Ultimately, one might answer such a question by considering the functional contributions of wetlands and beaches to the environment, and by comparing those benefits with the cost of ensuring that wet-

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[96] *See* TABLE III *supra*.

lands survive rising sea level.[97] The existing federal wetland program consists primarily of the acquisition of coastal habitat and a regulatory program that discourages dredging and filling of wetlands.[98]

One might infer from these programs that the nation has decided that it is important to retain a large fraction of the coastal wetlands found in nature. The nation accepts the wetland destruction that has already taken place, and small isolated additional losses of habitat. But it would not accept the destruction of most or all wetlands seaward of existing coastal development, let alone the loss of wetlands in areas that are currently undeveloped. Yet, that is exactly what would happen under current policies as sea level rises. Therefore, it follows that either there is something unique about sea level rise that would lead us to accept habitat destruction that we would otherwise reject or, that society wants to retain its wetlands as sea level rises and simply has an outmoded program that needs to be rectified to recognize the implications of retreating shores.

Both explanations are probably true to some extent. Allowing wetlands to survive in areas that have already been developed, at least through a policy of retreat, would require the abandonment of existing communities. Such an objective seems more drastic than existing programs, which merely keep new development from destroying existing wetlands. Moreover, a net loss in wetlands might be inherent to sea level rise, at least in terms of the total *area* of wetlands, given that there is less land just above the wetlands than within the intertidal zone. If all shores are armored, not only would the area of wetlands decline, but the total *length* of the natural shoreline and the portion of the shore covered with wetlands would decline. Armoring the shore would also undo many of the accomplishments of coastal wetland protection programs. As we see in Figure 2 *infra*, our programs virtually guarantee that in the long run we will see the very situation that people are prohib-

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[97] A formal cost/benefit analysis does not underlie the existing regulatory wetland protection program.

[98] *See* discussion *supra* in Introduction. As shown below, those programs were not designed to deal with sea level rise.

ited from creating directly: dry land, houses, and bulkheads will appear where wetlands and beaches would otherwise be.

What is a reasonable goal for wetland loss as sea level rises? Since the Administration of President George H.W. Bush, the federal[99] government has had the objective of *no net loss* of wetlands.[100] Even without human intervention, a large rise in sea level would cause a net loss of wetland area, therefore, such an objective does not seem realistic. No net loss may require affirmative human tampering with the environment to promote accretion.[101]

A more modest objective would be *no net loss of wetlands due to development*, which could be defined as allowing wetlands to adjust naturally and not holding back the sea. That is, no additional shoreline armoring. This type of policy would be somewhat analogous to the common policy along the ocean, where shoreline armoring that eliminates beaches is prohibited, but beach nourishment to hold back the sea is allowed. Under this definition, no *net* loss would require mitigation along the following lines: for every acre of dry land protected from the rising sea, an acre of wetlands would have to be created through excavation, artificially elevated through wetland accretion technologies, or alternatively, a rolling easement

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[99] Both the federal and state governments have important roles in wetlands protection. As demonstrated in TABLE III *supra* the states issue policies regarding coastal protection and also regulate land use. The federal government, however, requires a federal permit to fill wetlands. Nevertheless, states play a role here as well. In some cases, the states administer the federal program, and in other cases, they have their own regulations in addition to the federal requirements.

[100] *See* U.S. EPA AND U.S. ARMY CORPS OF ENGINEERS, MEMORANDUM OF AGREEMENT BETWEEN THE DEPARTMENT OF THE ARMY AND THE ENVIRONMENTAL PROTECTION AGENCY CONCERNING THE DETERMINATION OF MITIGATION UNDER THE CLEAN WATER ACT SECTION 404(B)(1) GUIDELINES (1990) (last modified Dec. 5, 1997) <http://www.epa.gov/OWOW/wetlands/ regs/mitigate.html> (announcing Bush Administration commitment to no net loss). *See also* CLINTON ADMINISTRATION WETLANDS POLICY (last modified Aug. 21, 1997) <http://www.epa.gov/ OWOW/wetlands/WetPlan/wetplan4.html>.

[101] *See* U.S. EPA, GREENHOUSE EFFECT, SEA LEVEL RISE, AND COASTAL WETLANDS 14-15 (1988) (showing that with the concave shore profiles, there will be a net loss of wetlands as sea level rises unless wetlands accrete enough to keep pace with the sea) (last modified Aug. 25, 2000) <http://www.epa.gov/ globalwarming/reports/pubs/sealevel/index.html>.

would have to be purchased for land whose owners already had a right to hold back the sea.

While "no net loss due to development" is more modest than "no net loss," the former is still probably far more protective of the environment than our political process would support. Realistically, the most feasible and environmentally protective policy would be to grandfather existing development, and then provide for no net loss of wetlands due to future development. Under this policy, some existing development might still be abandoned to the sea by selling rolling easements to people who want to hold back the sea in areas that have not yet been developed. Such an approach would be roughly analogous to a wetland mitigation trading program in which wetlands must be created *when the shore erodes or the sea rises* in return for wetlands elsewhere being lost due to property being protected.

The existing amount of coastal development does not necessarily represent an optimal mix of economic growth and environmental protection; it is simply the condition we have. Most states are probably unwilling to commit themselves to allowing wetlands to migrate inland in all areas that have not yet been developed. Therefore, rather than merely grandfather existing development, a state might create a plan that specified which wetlands should be kept and which should be sacrificed, with the latter including both areas that are already developed, and areas that are expected to be developed soon. Such a plan would be roughly analogous to the type of decisions that go into a local land use plan, except the focus would be on the tidelands, which are owned by the state. Viewing this plan as a baseline, one might then allow for transferable shore protection rights, analogous to transferable development rights, so that the market could exploit any inefficiencies resulting from the state plan. Some of the areas that have already been developed, for example, may be expensive to protect, in which case the owners of those properties might wish to sell their shore protection rights to someone whose property could be more inexpensively protected.[102] Alternatively, if some property with a

[102] Actually, the potential value of the permit would be equal to the value of the property minus the cost of protection. Hence, owners with either lower property values

shore protection right was inland or an area where allowing wetlands to migrate inland would be particularly important, a conservancy could team up with a developer to buy the property. The developer could keep the transferable shore protection right so that he could develop another parcel of land, and then donate the land to the conservancy.

4. Should We Prepare for Sea Level Rise Now or Later?

The fact that eventually we will either hold back the sea or allow it to flood a particular parcel of land does not, by itself, automatically imply that we must decide today what we are going to do. A community that will not need a dike until the sea rises two feet has little reason to build that dike today. Nevertheless, if the land where the dike would eventually be constructed happens to be vacant, the prospect of future sea level rise might be a good reason to leave the land vacant. A homeowner whose house will be inundated in thirty to fifty years has little reason to move the house back today, since she can enjoy the proximity to the water for several decades and, perhaps, even the rest of her life. Yet if the house happened to be destroyed by fire, it might be advisable to rebuild the house on a part of the lot that would provide it with a longer life.

Whether we need to be concerned about long-term sea level rise ultimately depends on the lead time of our response options and on the costs and benefits of acting now versus later. A fundamental premise of cost-benefit analysis is that resources not deployed today can be invested profitably in another activity and yield a return on investment. Therefore, if a particular response *can* be delayed with little or no cost, it *should* be delayed. Most engineering responses to sea level rise fall into that category. Dikes, seawalls, beach nourishment, jacking up structures and elevating roadways are unlikely to cost more a few decades hence than today, and they can be implemented within the course of a few years. To the extent that this is our response to sea level rise, we do not need to do it today. However, there are two exceptions.

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or more expensive protection costs would tend to sell permits to people with low protection costs or higher property values.

The first exception might be called the "retrofit penalty" for failing to think long-term. If one is building a road or a drainage system anyway, then it may be far cheaper to design for a rise in sea level than to come back later, because in the latter case, the project needs to be built twice. For example, while designing a drainage system for a particular watershed in Charleston, South Carolina would only cost an extra five percent to design for a one-foot rise in sea level, if the sea rises one foot the system would have to be rebuilt.[103] Even here, of course, delay may be justified depending on how long the one-foot rise in sea level would take, because $3 invested in Treasury Bonds would be $100 in a century. The design and siting of a house may be another example. If a house is designed to be moved, it can be moved, but a brick house on a slab foundation could be more problematic. Similarly, the cost of building a house twenty feet farther from the shore may be minor if the lot is large enough, whereas moving it back twenty feet may cost $10,000.[104]

The second exception concerns the incidental benefits of doing something sooner. If a dike is not needed until the sea rises two feet because at that point a one hundred year storm would flood the streets with four feet of water, the community is implicitly accepting the four feet of water that such a storm would provide today. If a dike is built now, then it would stop this smaller flood as well as protect from the larger flood that will eventually occur. This reasoning was instrumental in leading the British to build the Thames River Barrier, which protects London. Some people argued that this expensive structure was too costly given the small risk of London flooding, but rising sea level meant that such a structure would eventually have to be built. Hence, the Greater London Council decided to build it during the 1970s.[105]

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[103] *See* James G. Titus, et al., *Greenhouse Effect, Sea Level Rise, and Coastal Drainage Systems,* 113 J. WATER RESOURCES PLANNING AND MANAGEMENT 223 (Mar. 2, 1987).

[104] Smith & Tirpak *supra* note 48, at app. B 3-37, 3-75 (reporting that houses at Long Beach Island, New Jersey can be moved for $10,000 per house).

[105] *See, e.g.,* S. GILBERT & R. HORNER, THE THAMES BARRIER (1984).

While most engineering responses can be delayed with little penalty, the same can not be said about land use decisions. Once an area is developed, the cost of vacating it as the sea rises is much greater than that cost would have been if the area was not developed. This is not to say that eventual inundation should automatically result in placing land off-limits to development. Even if a home has to be torn down fifty to one hundred years hence, it might still be worth building. In some coastal areas where demand for beach access is great, rentals may cover the cost of home construction in less than a decade. However, once an area is developed, as a practical matter, it will not be abandoned unless either the eventual abandonment was part of the original construction plan, or the owners could not afford to hold back the sea.[106] Therefore, the only way to ensure that we continue to have natural shores would be to make such a decision before an area is developed. Due to coastal development today, a failure to deal with this issue now is, in effect, a decision to allow the loss of wetlands and bay beaches wherever development takes place.

In a previous article, this author showed that state governments could, if they so chose, allow wetlands to survive rising seas without significantly hurting property owners through a combination of setbacks, rolling easements, and density restrictions.[107] Allowing these ecosystems to migrate inland is ultimately a question of property rights, which are generally a matter of state law.[108] Moreover, in most states, the public owns the wetlands up to mean high water, with the State Government acting as the trustee responsible for managing these tidelands for the benefit of the people.[109]

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[106] This author has been unable to find any case where bayfront homeowners were required to abandon homes so that wetlands could migrate inland, and only a few states have prohibited efforts to hold back the sea along the ocean when a structure was threatened.

[107] *See, e.g.,* Titus, *Rising Seas supra* note 61.

[108] *See* Lucas v. South Carolina Coastal Council, 505 U.S. 1003, (1992) (if a regulation totally destroys the value of a property, then it will be a taking unless the restriction is one that the "background principles of the State's law of property and nuisance already place upon land ownership.")

[109] *See* Titus, *Rising Seas supra* note 61, at 1364-68.

The fact that states could, if they so chose, solve an environmental problem does not by itself mean that they will. The major federal environmental statutes all were passed after Congress had concluded that the states were unlikely to clean up the air and water, and were unlikely to preserve coastal wetlands on their own.[110] Under our current system, the federal government sets the overall objectives, and sometimes the general means of achieving those objectives, while the states apply those general requirements to the specifics of their unique situations.

As I will discuss in Part II, the federal government's wetland protection program is not facilitating the gradual abandonment of low-lying areas necessary to save our coastal wetlands as sea level rises. In most cases, this program behaves as if the sea was not rising. Moreover, other federal programs tend to encourage investment in low-lying coastal areas that would tend to lead people to hold back the sea rather than allow wetlands to migrate inland.

This situation does not reflect a conscious decision to sacrifice our wetlands and beaches as sea level rises. Rather, the policies were developed without regard to sea level rise and before most researchers recognized the possibility of a large rise within the time horizon of existing policies. People want to be near the water's edge, so they develop as close as possible without actually being on the wetlands. Later, as the shore retreats, people naturally want to protect homes, and the intertidal wetlands and beaches act essentially as a sacrificial anode.[111] Our institutions did not consciously decide to sacrifice wetlands and beaches—far from it—but they have not yet devised a way of avoiding that eventuality, given the combination of retreating shores and a desire to build near the shore.

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[110] *See* §101 of the Clean Air Act, 42 USC §7401 (1995) (declaring that pollution control is a state and local responsibility, but that it requires federal leadership) *and* the Clean Water Act, 33 USC § 1251 (1986) (declaring a series of national goals for water pollution control, while emphasizing that pollution control is primarily a responsibility of the states).

[111] A sacrificial anode is a piece of metal, usually zinc, attached to another piece of metal, such as the steel hull of a ship, that protects the steel from rust by preferentially attracting ions so that the anode rusts entirely before any of the steel rusts.

II. IMPLICATIONS OF SEA LEVEL RISE FOR SPECIFIC FEDERAL PROGRAMS

The federal government is likely to have numerous impacts on how our ecosystems adjust to rising sea level. We can roughly divide the federal government into five separate roles: property owner, regulator, program administrator, coordinator, and sponsor of research. This part of the article focuses on the federal role as a property owner and regulator, with a brief discussion of other federal programs. Currently, existing federal landholdings seem likely to facilitate wetland migration, even though no one considered rising sea level when the land was acquired. By contrast, the federal regulatory program is not facilitating landward migration, both because the statute does not encourage activities to ensure that wetlands survive rising sea level, and because the regulators are not even taking the measures that could be taken under existing statutes.

A. THE FEDERAL GOVERNMENT AS A PROPERTY OWNER

The federal government currently owns a large fraction of the land below the five-foot and ten-foot contours. The U.S. Fish & Wildlife Service (USF&W), the National Park Service, the Department of Defense, the Department of Agriculture's Forest Service, and other agencies all have large coastal landholdings. Wetlands and beaches are more likely to be able to migrate landward in these areas than in areas where private owners have or are likely to develop the land. Watersheds are more likely to be protected as well. Much of these lands are explicitly parts of conservation areas.

Even land that is not part of a conservation area may be more likely to retreat than privately held lands. A particularly stark example of the National Park Service commitment to a retreat policy can be found in North Carolina. The Park Service spent $11.8 million to move the Cape Hateras Lighthouse 1600 feet landward on a special railroad track because this was more cost effective than armoring the shore, given the Park Service's commitment to prevent the historic lighthouse from

toppling into the sea.[112] National seashores generally avoid constructing major infrastructure in areas likely to be threatened by erosion and have adopted a pro-retreat approach. Even defense installations may be more likely to allow wetlands to migrate inland, since the federal government could simply adopt a retreat policy without encountering the wrath of private property owners.

The most important coastal conservation lands are those within the National Refuge System, administered by the USF&W. The National Wildlife Refuge Administration Act[113] directs the Secretary of Interior to manage these lands to conserve fish, wildlife, plants, and habitat for the benefit of both the present generation and future generations.[114] The genesis of the system was President Theodore Roosevelt's executive order creating Pelican Island Federal Bird Reservation in the Florida Everglades.[115] The system has also acquired land[116] and accepted donations.[117] The USF&W's policy is to purchase the minimum interest in land necessary to accomplish a conservation purpose.[118]

National wildlife refuges generally were not designed with an eye toward the eventuality of sea level rise, which is understandable given that they were mostly set up before the 1980s

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[112] *See* U.S. DEP'T OF THE INTERIOR, NAT'L PARK SERV., CAPE HATTERAS LIGHTHOUSE RELOCATION ARTICLES AND IMAGES (last modified Nov. 5, 1999) <http://www.nps.gov/ caha/lrp.htm> (discussion of the project to move the lighthouse). *See also* U.S. DEP'T OF THE INTERIOR, NAT'L PARK SERV., MOVING THE CAPE HATTERAS LIGHTHOUSE (last modified Nov. 5, 1999) <http://www.nps.gov/caha/moving.htm> (explaining that the lighthouse was moved 2900 feet, leaving it 1600 feet from the shore).

[113] *See* 16 U.S.C. § 668dd-668ee (1985).

[114] *See id.* at § 668dd(a)(4)(A-B).

[115] *See* U.S. FISH & WILDLIFE SERVICE, HISTORY OF THE NATIONAL WILDLIFE REFUGE SYSTEM (last modified Jan. 11, 1999) <http://bluegoose.arw.r9.fws.gov/nwrsfiles/General/History. html>.

[116] *See* U.S. FISH & WILDLIFE SERVICE, HOW REFUGE UNITS ARE ACQUIRED (last modified Jan. 11, 1999) <http://bluegoose.arw.r9.fws.gov/nwrsfiles/General /NWRSEstablishment.html>.

[117] *See* 16 U.S.C. § 66dd(b)(2) (authorizing the Secretary of Interior to accept cash donations for acquiring lands).

[118] *See id.*

when sea level rise became a concern.[119] Fortunately, the refuges along the coast generally include some high ground as a buffer between the wetlands and existing and future development. Unfortunately, this purpose is sometimes satisfied without a large acquisition of upland, for example, when a bay separates a reserve's island wetlands from the farms on the mainland. For example, only a few percent of Blackwater Wildlife Refuge in Maryland is above the five-foot contour.

No one has yet analyzed the extent to which our national refuges would be affected by rising sea level. In fact, there does not even appear to be a useful nationwide data set that would enable someone to analyze this question, because the federal government has not yet mapped federal lands in a geographic information system (GIS) format.[120] The best available information appears to be the Nature Conservancy's data set of managed lands. Although that data set is not comprehensive, it does include most federal wildlife refuges, state refuges, parks, and even private lands that are managed for conservation for the mid-Atlantic States. Table IV *infra* shows the area of these lands below the 1.5 and 3.5 meter contours.

Within the states depicted, conservation areas account for twenty-five percent of the land below the 1.5 meter contour, but only nine percent of the land between 1.5-3.5 meters. Thus, if sea level rises and people do not attempt to hold back the sea, not only would the amount of wetlands in conservation areas decline, but it would decline by more than the nationwide loss of wetlands. While managed lands would at least allow some wetlands to migrate inland, they are not set up to even maintain their current share of what would be a shrinking coastal zone. Whether or not these results would apply to the federal refuges, it seems reasonable to conclude that the national wildlife refuge system needs to play a role in any effort to ensure that a sufficient area of wetlands survives rising sea level.

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[119] *See generally* J.S. HOFFMAN ET AL., PROJECTING FUTURE SEA LEVEL RISE (1983) (explaining that people are not considering sea level rise in long-term decision making because no one had previously estimated how much the sea is likely to rise due to greenhouse gases).

[120] *See* Memorandum to James Titus from Kim Balisiano (summarizing lack of decent GIS maps of federal lands) (on file with author).

TABLE IV: AREA OF MANAGED LANDS CLOSE TO SEA LEVEL[121]

	Percentage of Low Lands			
	Managed by Elevation		Managed for Conservation	
State	0-1.5 meters	1.5-3.5 meters	0-1.5 meters	1.5-3.5 meters
DC	0.0	0.1	0	7
DE	79.3	13.7	53	21
MD	132.3	30.9	22	10
NC	578.9	125.5	26	8
NJ	139.6	41.8	33	17
NY	2.8	6.8	3	7
VA	39.6	8.7	11	2
Totals	972.5	227.5	25	9

The USF&W is not yet seriously preparing for the consequences of sea level rise. Thus far, the Service does not appear to have a single land or easement acquisition in anticipation of accelerated sea level rise, nor has it taken any action to anticipate sea level rise. In spite of the agency's failure to consider sea level rise, however, its refuge system contains wetland ecosystems that are more likely to be able to migrate inland than ecosystems outside their system. The reason for this is that USF&W would allow the wetlands to migrate inland, whereas private owners would often choose to armor their shores.

The portion of the coastal zone incorporated into the national refuge system did not result from a rigorous analysis of the costs and benefits. Rather, it resulted from a combination of the federal commitment to preserve ecosystems and opportunities to acquire undeveloped land at a reasonable cost. Therefore, it is difficult to make a compelling argument for any particular level of wetland protection. As discussed in Part I, a goal of "no net loss" of wetlands would be consistent with other environmental policies on wetlands. However, in the context of a large rise in sea level, maintaining the current area would be

[121] *See* Richman & Balassiano email *supra* note 47.

difficult. A more modest objective might be to ensure that a refuge continues to occupy the same portion of the shore as today. That is, ensure that all refuges have acquired land or easements up to the ten or fifteen-foot contour. This approach, however, might result in a large net loss of wetland acreage in many refuges where large marsh peninsulas and islands dominate. A third approach, which may become increasingly feasible as our understanding increases, would be to enumerate the critical functions of the existing refuge and identify the area of wetlands that would be necessary to preserve those functions if sea level rises.

Whatever area of wetlands must be preserved, USF&W would have a variety of tools for achieving wetland migration. The most obvious is additional land acquisition. However, such an approach does not limit itself to the "minimum interest" required to the goal of saving wetlands as sea level rises, since the land ends up in the hands of the federal government long before sea level rise necessitates it.[122]

The most narrowly tailored approach would be for USF&W to acquire rolling easements on all property likely to be inundated in designated areas where it is critical for those wetlands to exist instead of development.[123] By purchasing a rolling easement from coastal farmers, the federal government would essentially give a cash payment in return for an agreement that present and future owners will not erect structures or elevate the land in such a way that would prevent the sea from rising enough for inundation to occur. The farmer who thinks that global warming is nonsense would not perceive himself as giving up anything, since if the sea never rises, it will not matter that he was prevented from erecting a dike. In most cases, a rolling easement would cost a few percent of the fair market value of the land. Regardless of whether a particular state recognized the rolling easement as a property right, federal supremacy would enable USF&W to purchase such easements.

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[122] *See* 16 U.S.C. § 668dd(b)(2) (1985).

[123] *See* discussion *supra* Part I (explaining that a rolling easement is a property right that enables the holder to prevent the servient estate from constructing anything that prevents the shore from eroding naturally).

Another option would be to purchase non-development easements.

An important limitation to any policy of additional land acquisitions is that in some regions and among some people, federal landholdings are viewed with great suspicion. Grants to state governments to purchase lands and easements could potentially work as well, without arousing as much anger among those who oppose federal land ownership.

Although USF&W has the primary responsibility for purchasing coastal ecosystems, several federal agencies own land with important habitat. Of those agencies, the Park Service may be at the forefront in recognizing issues relating to sea level rise. Structures tend to be light so as to accommodate relocation or abandonment as the sea rises.

The Department of Defense owns many square miles of coastal lands. In some cases, the need to protect a facility important to national security, or the inherent needs of a naval port, will make shoreline armoring inevitable. Nevertheless, the Army Corps of Engineers could work with the various branches to ensure maximum protection of wetlands and beaches as sea level rises.

B. FEDERAL GOVERNMENT AS A REGULATOR

Because most coastal lands are in private hands, the federal government can only protect a minority of coastal wetlands through its role as a property owner. The regulatory program, by contrast, could have a much more universal impact if it were redesigned to save wetlands as sea level rises. However, doing so would require a much more drastic modification of existing programs than would be required to ensure that wetlands migrate inland along shores owned by the federal government. This section examines both how sea level rise could undermine the existing wetland program, and how the program might be redesigned to assist the landward migration of wetlands and beaches as sea level rises.

1. How Sea Level Rise Could Undermine the Wetland Protection Program

Setting aside coastal lands has been only one part of the federal program to preserve the coastal environment. More

pervasive has been the federal regulatory program controlling the dredging and filling of coastal wetlands. Section 10 of the Rivers and Harbors Act of 1899 and Section 404 of the Clean Water Act require a permit to dredge or fill any portion of the navigable waters of the United States.[124] Courts have long construed this jurisdiction to include lands within the ebb and flow of the tides.[125]

In order to fill coastal wetlands on private property, an owner must obtain a permit from the Army Corps of Engineers with the consent of the EPA.[126] As a practical matter, and in light of the current no net loss policy, these permits are generally not issued unless the activity is inherently water related, such as a marina.[127] Even then, the owners generally must

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[124] *See* The Clean Water Act of 1977, § 404, 33 U.S.C. § 1344 (1994) (regulating the manner in which dredge or fill material can be disposed of in navigable waterways); *accord* The Rivers and Harbors Act of 1899, § 10, 33 U.S.C. §§ 403, 409 (1994) (declaring it unlawful to fill navigable waterways without the permission of the Corps of Engineers).

[125] *See* Gibbons v. Ogden, 22 U.S. 1, 217-18 (9 Wheat. 1824) (holding that the federal government has exclusive jurisdiction over commerce in the coastal waters). *See also id.* at 271-72, 276 (holding that the congressional power to regulate navigable waterways under the Commerce Clause implies a navigation servitude, so that the government's interference with private riparian rights along inland navigable waterways does not require compensation). *See, e.g.,* Zabel v. Tabb, 430 F.2d 199, 215 (5th Cir. 1970) (holding that the navigation servitude includes the power to deny a permit to fill the marsh below mean high water without compensating landowners). *See also* Coastal Petroleum Co. v. United States, 524 F.2d 1206, 1211 (Ct. Cl. 1975) (holding that the navigation servitude includes a power to mine limestone and build levees on land below mean high water without compensating landowners). *See also* Guidelines for Specifications or Disposal Sites for Dredging or Fill Material, 40 C.F.R. § 230.3(s)(1) (2000) (explaining that in the context of §404 of the Clean Water Act, the term "waters of the United States" includes waters subject to the ebb and flow of the tides).

[126] *See* 33 U.S.C. § 1344(a) (1994). In the case of tidal wetlands, this authority was also provided in the Rivers and Harbors Appropriations Act of 1899, 33 U.S.C. §§ 403, 409 (1994). That statute was not used to protect large amounts of coastal wetlands, however, until the 1970s. *See Comment, Discharging New Wine into Old Wineskins: The Metamorphosis of the Rivers and Harbors Act of 1899*, 33 U. PITT. L. REV. 483, 486-89 (1972).

[127] "Where the activity associated with a discharge... does not require access or proximity to or siting within the special aquatic site in question to fulfill its basic purpose (i.e., is not `water dependent"), practicable alternatives that do not involve special aquatic sites are presumed to be available." 40 C.F.R. § 230.10(a)(3) (2000). Owners must demonstrate that there are no "practicable alternatives" to a particular development. *See id.* at § 230.10(a) (which includes a consideration of "cost, existing technology, and logistics in light of overall project purposes"). *See also* 40 C.F.R. § 230.3(q) (including the ability to purchase another piece of land that would work as well). *See also* 40 C.F.R. § 230.10(a)(2).

mitigate the loss of wetlands by creating or enhancing wetlands elsewhere.[128] There are, however, important exceptions to the general refusal to issue wetland permits, as well as the mitigation requirement, such as erosion control structures[129] or small parcels of land[130]. The statute requires the Corps of Engineers to consider both the impact of a particular permit and the cumulative impact of issuing many permits of a given class.[131]

Unlike the refuge program, the regulatory program to protect coastal wetlands does not inherently enable wetlands to migrate inland. While the natural tendency of a refuge manager is to acquire at least some of the dry land adjacent to coastal wetlands as a buffer, the regulatory program has no similar buffer. To the contrary, the statute creates a fairly bright line. The program limits discharges of fill into *navigable waters*, not land that might one day become navigable.[132] The Clean Water Act does not presently contain language that could reasonably be construed as prohibiting fill to elevate dry land, much less prevent the development that tends to make bulkheads inevitable. Existing regulations have conspicuously

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[128] A permit will only be issued if the permittee takes steps to minimize the potential impacts. *See* 40 C.F.R..§ 230.10 (d). *See generally* U.S. ENVIRONMENTAL PROTECTION AGENCY & U.S. ARMY CORPS OF ENGINEERS, MITIGATION MEMORANDUM OF AGREEMENT 4 (Feb. 6, 1990) (explaining the federal policy on wetland mitigation under section 404(b)(1) of the Clean Water Act and that "[a]ppropriate and practicable compensatory mitigation is required for unavoidable adverse impacts which remain after all appropriate and practicable minimization has been required.")

[129] *See* Proposal to Issue, Reissue, and Modify Nationwide Permits, 61 Fed. Reg. 30,779, 30,787, 30,788 (June 17, 1996) (explaining that construction of erosion control structures is authorized, as long as they meet certain conditions).

[130] *See* Issuance of Nationwide Permit for Single-Family Housing, 60 Fed. Reg. 38,650, 38,662 (July 27, 1995) (allowing property owners to fill up to one-half acre of wetlands).

[131] *See* 33 U.S.C. § 1344(e)(1) (stating that the Secretary of the Army may issue general permits for any category of activities involving discharges of dredged or fill material if the Secretary determines that the activities in such category are similar in nature, will cause only minimal adverse environmental effects when performed separately, and will have only minimal cumulative adverse effects on the environment). *See also* Issuance of Nationwide Permits for Single-Family Housing, 60 Fed. Reg. 38,654 (July 27, 1995) (promising that District Engineers will take measures to avoid a significant cumulative impact from a nationwide permit that allows property owners to fill up to one-half of an acre for single family homes).

[132] *See* 33 U.S.C. § 1344(a) (1994).

avoided any indication as to whether developers should create buffers that might enable wetlands to migrate inland.[133] As such, the statute as written could not be construed as a mandate for a full scale regulatory program to prevent development of the land onto which the wetlands would eventually migrate.

Nor does the regulatory program currently encourage the rolling easement approach.[134] In fact, the Corps of Engineers has issued a nationwide permit for bulkheads and other erosion-control structures, effectively ensuring that wetlands will not be able to migrate inland. [135] The statute required the Corps to consider the cumulative impact of issuing thousands of permits.[136] Because this permit prohibits filling of vegetated wetlands and allows very limited filling of non-vegetated wetlands,[137] the Corps concluded that the impact was minor.[138] For example, bulkheading one hundred feet of shoreline would only destroy a few hundred square feet of non-vegetated wetlands, implying that bulkheading one mile of shoreline would only involve direct destruction of about one acre of wetlands. Thus,

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[133] See Federal Guidance for the Establishment, Use, and Operation of Mitigation Banks, 60 Federal Register 58,605, 58,609 (Nov. 28, 1995) ("Credit may be given for the inclusion of upland areas within a [wetland mitigation] bank only to the degree that such features increase the overall ecological functioning of the bank.") Enabling wetlands to migrate inland does not literally "increase" functionality, although it would promote an ecosystem's longevity. The failure to offer any guidance, however, on the credit for adding longevity to an ecosystem that might otherwise be destroyed as the sea rises, indicates that the federal agencies promulgation of the guidance was not contemplating this issue, and hence one should not assume that the current regime would offer any value in return for ensuring that wetlands survive sea level rise. At the same time, the overall logic of allowing inclusion of adjacent uplands would support such an extension of the published guidance.

[134] The limits of credit for purchases of uplands would presumably apply to easements as well. *See id.*

[135] *See* 61 Fed. Reg. 65,873, 65,915 (Dec. 13, 1996) (reissuing Nationwide Wetland Permit 13, Bank Stabilization activities necessary for erosion prevention). *See also* Proposal to Issue, Reissue, and Modify Nationwide Permits, 61 Fed. Reg. 30,779, 30,787, 30,788 (June 17, 1996) (explaining that construction of erosion control structures is authorized, as long as they meet certain conditions).

[136] *See* 33 U.S.C. § 1344(e).

[137] *See* 61 Fed. Reg. 65,913, 65,915 (Dec. 13, 1996) (Nationwide Permits and Conditions, Permit 13: Bank Stabilization, Conditions c and d).

[138] *See* ARMY CORPS OF ENGINEERS, FINAL DECISION DOCUMENT, NATIONWIDE PERMIT NO. 13, para. 4(e)(iv) (1996) (last modified Apr. 4, 2000) <http://www.spk.usace.army.mil/cespk-co/ regulatory/FDDs/fdd-13.html>.

the Corps concluded that 800 projects per year would only destroy about eighty acres of wetlands per year, with some the projects being large enough to result in mitigation of about seven acres per year.[139] By that logic, of course, permits could be issued for armoring the entire coastal zone of the the United States and only a few square miles of coastal wetlands would be lost.

There are two fundamental problems with this reasoning that underlies the nationwide permit for bulkheads. First, given that the entire motivation of shore-protection structures is to stop the gradual landward migration of the intertidal zone, it is somewhat myopic to focus only on the wetlands that are directly destroyed by the shore-protection rather than the total impact, which also includes stopping wetlands and beaches from forming inland. The important impact of armoring a mile of shoreline is not the acre of beach or wetlands filled in building the bulkhead, but rather, the eventual conversion of a wetland shore to an area with open water splashing against a wall. Rather than merely report the area that is directly destroyed, the Corps' analysis ought to report the eventual net loss in wetlands that results by preventing the landward migration of vegetated and non-vegetated wetlands.

The second problem with the nationwide wetland permit system and its underlying approach is that the focus on the *area* of wetlands lost may not always be the best way of viewing what is lost. For some species of fish that rely on finding a marsh at will, the length of marshy shorelines may be as important as the area of wetlands. Eliminating a strip of marsh ten miles long and ten feet wide may be far more valuable than a compact area 700 feet long and 700 feet wide, even if both have the same area. Ten miles of narrow sandy beach is even less equivalent to a compact area of wetlands, and in some areas narrow sandy beaches are becoming scarce. Moreover, a long, narrow intertidal shore represents public access and a place for boats to land in an emergency. The Corps' failure to consider the loss of beaches is particularly ironic because of the importance of beaches for navigation, which was the original

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[139] *See id.*

justification for the Corps' jurisdiction for the wetlands program.[140] Rather than simply report the acreage of wetlands lost, the Corps' analysis should report the length of wetland shores, sandy beaches, and mudflats that will be replaced with shoreline armoring.[141]

Overall, the federal regulatory program is making no effort to enable wetlands to migrate inland as sea level rises. We now provide a few examples where at least something could be done in the right direction, while acknowledging that Congress and the President would have to make this a priority for a comprehensive solution.

2. Opportunities for EPA Regulators to Enable Wetlands to Migrate Inland

The most important step that EPA and the Corps of Engineers could take would be to revise the nationwide permit for bulkheads. Depending on the level of wetland protection desired in a given area, the federal regulators have a wide spectrum of options at their disposal. Those options include:

a. Deny bulkhead permits in areas where critically important wetlands are being eliminated beyond an acceptable extent. For example, in areas where the loss of bay beaches is harming navigation or the environment, deny all permits—effectively requiring homeowners to use soft engineering approaches like beach nourishment;

b. Include as a condition on all bulkhead permits the creation of marsh or beach to front the bulkhead;

c. Apply a mitigation requirement along with all bulkhead permits. For example, if someone wants to erect a 200 foot bulkhead that will eliminate 200 feet of beach, they must mitigate that loss. In principal, the mitigation need not be 1:1. For example, if EPA

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[140] *See generally id.*

[141] The fact that the Corps cannot stop development in areas above high water does not imply that it should ignore the eventual environmental impacts of current permits on areas that are currently above high water, especially when those impacts will occur as a result of sea level rise bringing the land within the ebb and flow of the tides and, hence, within the Corps' jurisdiction.

were to determine that a fifty percent reduction in natural shores is acceptable, the mitigation requirement might be to restore 100 feet of shore for every 200 foot bulkhead. As discussed above, pro-rata contributions for rolling easements would be one way to effect such mitigation; and

d. Give property owners short-term shore protection in return for long-term environmental protection by, for example, issuing bulkhead permits with limited lifetimes that would expire after which time the property owner would agree to not seek a permit.

A second opportunity concerns mitigation. Currently, property owners seeking to fill wetlands might get a permit if they create wetlands elsewhere with a greater environmental benefit.[142] Often, one must create two acres for every acre that one destroys.[143] The reason for this mitigation penalty is that the regulators are often suspicious of both the quality and the longevity of wetlands that are artificially created. While this concern may have merit, the converse may also apply: if sea level rises, the wetlands that were being destroyed may not have lasted forever either. If longevity is a goal in mitigation, then one option would be to require permit seekers to demonstrate that the mitigation will last even if sea level rises several feet due to global warming. An example response that might satisfy the regulators would be the creation of an acre of wetlands along with the purchase and donation of rolling easements along either the shoreline where the mitigation project is, or a similar stretch of shoreline inland of some undisturbed wetlands that are adjacent to farmland that might be developed some day.

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[142] *See id.*

[143] *See Wetlands: Controversy and Confusion*, THE VOLUNTEER MONITOR: THE NATIONAL NEWSLETTER OF VOLUNTEER WATER QUALITY MONITORING 1 (EPA Office of Water & Alliance for the Chesapeake Bay, eds.) (Spring 1998) ("Mitigated wetlands are often designed to be twice the size of the destroyed wetland.") *See also* C. DEMING COWLES, ET AL., GUIDANCE ON DEVELOPING LOCAL WETLANDS PROJECTS: A CASE STUDY OF THREE COUNTIES AND GUIDELINES FOR OTHERS (1991) (last modified Oct. 7, 1997) <http://www.epa.gov/OWOW/wetlands/partners/local.html> ("[g]enerally, the County seeks restitution for wetlands loss, penalties or additional mitigation on a two for one basis.")

Enforcement would offer similar opportunities. Currently, when EPA and the Corps find a violation, they can negotiate mitigation as one of the conditions.[144] Those mitigation requirements could be structured to ensure that the wetlands created by such mitigation survive rising sea level.

All of these measures are simply piecemeal, and would not protect the entirety of our coastal zone. Nevertheless, they may be worth pursuing both because at least some ecosystems could be protected, and because they develop at least some expertise in dealing with the problem, expertise on which Congress and the President might rely if a more general solution was going to be imposed.

3. Legislative Options

It would be within the power of the executive branch to begin preparing for sea level rise because doing so would simply amount to a technical correction of an existing program in light of new scientific information. Congress clearly wanted to protect wetlands from filling, and it wanted the cumulative environmental impact to be considered and mitigated. Failing to consider the ramifications of sea level rise on the success of wetland protection programs is a technical mistake, and within the duty of the President to "take care that the laws be faithfully executed."[145]

A policy of ensuring that ecosystems migrate inland as sea level rises, however, would be more than a technical correction. Like the decisions to clean the nation's air and water, it would involve a policy tradeoff between environment and the economic interests of property owners. Even if existing statutes can be read as providing the executive branch such discretion, this is the type of policy more appropriate for a legislature.

In a previous article, this author argued that states can implement the necessary policies to allow wetlands and beaches to migrate inland, and that it would be proper to do so because

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[144] *See* In the Matter of Urban Drainage and Flood Control District, Docket No. CWA-VIII-94-20-PII, 20-26 (June 4, 1998) (EPA Office of Administrative Judges decision discussing mitigation plan that had been negotiated with the Corps of Engineers to remediate damages from wetland violation).

[145] U.S. CONT. amend. II, § 3.

land use is generally a state and local responsibility.[146] Nevertheless, the federal government has been the primary instigator for wetland protection in the past. Therefore, any effort to consider the entire spectrum of policy responses should consider the possibility that the federal government might also lead the way in adapting its own programs so that they will work if the sea rises substantially in the decades ahead.

A complete examination of this question is beyond the scope of this article. Nevertheless, I will briefly discuss two possible models: a revision of the existing wetland protection program to ensure that it will work in the long run, rather than fail as sea level rises and setting overall performance goals for the states, while charging them with meeting a target.

a. Expansion of Existing Program

If sea level rises a few meters over the next few centuries, everything that the federal wetlands protection program has accomplished in the coastal zone will ultimately come to naught because the wetlands that were protected will be under water. If Congress wanted the wetlands to survive sea level rise, the simplest extension would be to *require a permit to fill navigable waters or lands that are likely to become navigable.* Such an amendment would give EPA and the Corps of Engineers the ability to stop the filling of dry land along the shore, which means that as the sea rises, the land would eventually be inundated and become wetland. This approach would not stop construction, because construction by itself is not viewed as prohibited fill if, for example, a house is being built on pilings.[147] Guidelines for such a system might grant the permit wherever the fill has no net loss. For example, a beach nourishment project could continue because such projects maintain beaches.

Such a policy might be objectionable on policy grounds because traditionally, federal jurisdiction over navigable waters

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[146] *See generally* Titus, *Rising Seas supra* note 61.

[147] Wetlands can be eliminated in either of two ways: elevate the dry land so that the land is never inundated and therefore, does not become wetland, or erect a dike or bulkhead. Such a provision would allow the Corps to regulate either situation, because bulkheads require a permit.

has stopped at the high water mark, and this approach would extend the jurisdiction inland. An alternative formulation might be for Congress to amend the statute so that a permit is required for bulkheads that stop the landward migration of navigable waters, effectively repealing the nationwide permit for bulkheads. At first glance, one might think that there would be no need for such an act of Congress because the executive branch could modify the nationwide permit. The difference, however, is that Congress taking such a measure would make landward migration of wetlands a national policy. Without such an enactment, the bureaucracy would probably find it difficult to deny permits to people about to lose their homes to a rising sea.

b. Setting Overall Performance Standards

Simply expanding the existing wetland protection program might not be the most reasonable way to enable wetlands to survive rising sea level. The underlying vision of the existing program is to save virtually all existing coastal wetlands, while being flexible only for trivial losses or losses that are mitigated with no net harm to the environment. In the context of sea level rise, such a vision is unrealistic. We are not going to abandon all of the low-lying areas to allow wetlands to migrate inland. An expansion of the existing program to require a permit to stop wetlands from migrating inland would be an indirect, and perhaps ineffective, way to address the problem unless there was explicit guidance as to when the permit should be issued.

A more direct approach would be for the federal government to set some sort of performance standard and allow states to develop plans as to how they would achieve the objectives. This is currently the approach taken by the Clean Air Act, which requires EPA to set national ambient air quality standards,[148] but authorizes states to decide how the limit will be met.[149] For example, a federal statute might mandate that an

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[148] *See* Clean Air Act § 109, 42 U.S.C. § 7409 (1995).

[149] *See* 42 U.S.C. § 7410.

independent EPA science advisory board or the National Marine Fisheries Service determine the maximum amount of shoreline habitat that can be safely eliminated as sea level rises, and then require states to prepare a State Implementation Plan, with the Corps of Engineers charged with developing such a plan if the state fails to prepare a plan by a specific time. Such an approach would base the level of wetland protection on sound science, while the means could be set by states. Presumably, states would ensure the protection of wetlands using setbacks, rolling easements, density restrictions, land acquisition, and various technological measures.

C. THE FEDERAL GOVERNMENT AS A PROGRAM ADMINISTRATOR

Regulatory and land management policies to protect wetlands as sea level rises could probably solve the problem because they would apply universally. Nevertheless, for completeness, it may be worth mentioning a few other programs that may help to protect wetlands as sea level rises.

1. National Estuary Program

Section 320 of the Clean Water Act authorizes a National Estuary Program. [150] The purpose is to conduct assessments and develop comprehensive conservation and management plans that protect the environment and the various uses of the estuary.[151] A program for a specific estuary is created by the governor of a state requesting such a program, with the EPA concurring.[152] Once a plan is developed, it can be implemented with the concurrence of EPA, the governor of the state affected, and other federal agencies required to take action.[153]

This program could play an important role in helping wetlands migrate landward for two reasons. First, unlike most of EPA's regulatory programs, the National Estuary Program focuses on what is actually necessary to preserve all of the various resources of an estuary, rather than implementing specific

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[150] *See* 33 U.S.C. § 1330 (1994).

[151] *See* 33 U.S.C. § 1330(b).

[152] *See* 33 U.S.C. § 1330(a).

[153] *See* 33 U.S.C. § 1330(f).

mandates of a statute.[154] The absence of a statutory mandate to ensure that wetlands survive rising sea level was one reason that EPA's wetlands program has not focused on this issue.[155] Second, the people in a given region need not await a national consensus to solve the problem before moving ahead to address the issue. So far, this author knows of only two estuary programs that address the issue. The Sarasota National Estuary Program's plan has long highlighted the issue, although nothing has been done as a result. More recently, the Maryland Coastal Bays program has listed this issue in its plan, roughly contemporaneous with modest efforts by the U.S. Department of Agriculture to ensure that some wetlands in the area can migrate inland.

2. Coastal Zone Management Program

Like the national estuary program, this program focuses on broad environmental objectives. The National Oceanic and Atmospheric Administration (NOAA) acts as both a cheerleader and an overseer for the states. The Coastal Zone Management Act makes state participation voluntary, and the program provides funds for states to develop and administer Coastal Zone Management Plans. The Act has guidelines for NOAA approval of the coastal plans, but its requirements are essentially procedural, mandating the types of issues that a state must consider for NOAA to approve the plan. Among other things, the Act specifically encourages states to protect wetlands, minimize vulnerability to flood and erosion hazards, and improve public access to the coast.[156] NOAA cannot, however, dictate the substance or require any specific level of environmental protection.

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[154] *See* ENVIRONMENTAL PROTECTION AGENCY, OFFICE OF WATER, ABOUT THE NATIONAL ESTUARY PROGRAM (last modified Apr. 10, 2000) <http://www.epa.gov/owow/estuaries/ about2.htm>.

[155] During the 1980s, EPA's Wetlands Office and its precursor, the Office of Federal Activities, generally opposed taking measures to address sea level rise. During 1984, then-director Alan Hirsch told the author that the absence of a statutory mandate made sea level rise low on his list of priorities. During 1986, the Office of Wetlands Protection opposed releasing EPA's first comprehensive study on the impacts of sea level rise on wetlands in part because people in Charleston, South Carolina had opposed EPA efforts to protect wetlands on the grounds that the wetlands will eventually be under water anyway.

[156] *See* 16 U.S.C. § 1452(2) (1992).

Congress has already provided some encouragement for states to consider the implications of sea level rise.[157] So far, this Congressional exhortation does not appear to have accomplished much beyond inducing NOAA to fund some studies. The Act has, at least, encouraged states to periodically designate specific staff to keep track of the issue.

Guidelines from NOAA on how to deal with the sea level rise issues might help a number of states. Alternatively, more specific language on responding to sea level rise might be added to the Act the next time it is amended. For example, the language might be modified to require state plans to articulate its vision of what will happen to its wetlands. Under such an approach, a state would be free to decide the portion of the shoreline it intends to armor, but would be required to take stock of where it is headed. The Coastal Zone Management Program is a powerful testament to the fact that planning alone can induce some improvements, and if a state's intentions were at odds with what its citizens wanted, articulating the plan would make it possible for the issue to be resolved.

3. National Flood Insurance Program

Under the National Flood Insurance Act, property owners in participating coastal communities can obtain federal flood insurance.[158] Although some critics have suggested that the program encourages people to build homes in hazardous areas, the direct effect of the program has been to encourage flood-resistant construction. One of the most important changes has been the tendency to elevate homes on pilings. In some cases, this elevation might make wetland migration more likely, because if a house is on pilings, a yard could gradually convert to marsh without threatening the home.

Nevertheless, in some cases, this program might tend to encourage property owners to continue inhabiting shorefront property for a longer time than would have been the case without the program. As the shore erodes, for example, the likelihood of severe damage from a storm increases. Currently,

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[157] *See* 16 U.S.C. § 1451(i) (2000).

[158] *See* 42 U.S.C. §§ 4001-4028 (1994).

however, the Federal Emergency Management Agency does not increase insurance rates to reflect the increasing risk. Therefore, these property owners may be receiving an artificially low insurance rate. FEMA is currently reconsidering this question, and may factor erosion into rates in the future.

4. Louisiana Wetland Loss

Coastal Louisiana is gradually submerging below the sea.[159] At one time, the sediment washing down the Mississippi River settled in the Louisiana delta's wetlands, enabling the wetlands to keep up with the rising sea level and the natural subsidence of the deltaic muds. Today, river levees, artificial river banks, and other activities prevent the sediment from reaching the wetlands, which no longer keep up with the rising water levels. Numerous activities are underway to address this situation, but the wetland loss continues.

5. Florida Everglades Restoration

A major federal interagency effort is currently underway to restore the Florida Everglades.[160] A key component of the restoration effort will be to increase the flow of freshwater south through the Everglades to prevent saline water from advancing into the freshwater ecosystems. Unfortunately, rising sea level could inundate a large part of the Everglades, enabling saltwater to advance upstream.[161] The review study report examines the implications of a small rise in sea level, but it candidly acknowledges that the model assumes that the edge of the mangroves are constant. A key impact of sea level rise, however, would be to enable the salt-tolerant mangroves to move inland; therefore, the model's key assumption is incorrect. The prospect of sea level rise probably does not invalidate the planned restoration. In fact, the increased salinity from sea level rise is one more reason why more fresh water will be needed in the

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[159] *See* U.S. ENVIRONMENTAL PROTECTION AGENCY & LOUISIANA GEOLOGICAL SURVEY, SAVING LOUISIANA'S COASTAL WETLANDS: THE NEED FOR A LONG-TERM PLAN OF ACTION (1987) (last modified Jan. 14, 2000) <http://www.epa.gov/globalwarming/publications/impacts/ sealevel/louisiana.html>.

[160] *See, e.g.*, U.S. ARMY CORPS OF ENGINEERS, ET AL., CENTRAL AND SOUTHERN FLORIDA COMPREHENSIVE REVIEW STUDY (1999) (last modified Mar. 21, 2000) <http://www.evergladesplan.org/pub_restudy_2.htm>.

[161] *See generally* Titus & Richman *supra* note 46.

Everglades. Sea level rise may, however, render the current restoration effort insufficient to achieve its objectives.

6. Construction in the Coastal Zone

Federal spending on infrastructure increases the likelihood that particular areas will be protected from rising sea level rather than allowed to gradually flood. For example, in Somerset County, Maryland, one finds many old homes that have been abandoned, often with failed septic systems. A number of communities around the town of Crisfield, however, have been connected to sewer. Given this infrastructure investment, it seems relatively unlikely that these communities will be abandoned to the sea. Had the sewer not been connected, by contrast, failing septic systems would have eventually induced people to leave these homes and the marshes would have taken over their property.

CONCLUSION

As the sea rises, our wetlands and beaches are migrating inland in undeveloped areas. In developed areas, however, people are engaging in a wide variety of activities to hold back the sea. Bay beaches are being replaced with walls of concrete, rock, steel, and wood. Ocean beaches, by contrast, are accreting upward rather than migrating landward, as communities pump sand onto their beaches.

So far, the impact of development on the migration of vegetated wetlands has been somewhere between the situations for bay and ocean beaches. Unlike beaches, the landward and seaward boundaries of vegetated wetlands do not necessarily migrate together. Along the landward boundaries of the wetlands, higher water levels are allowing coastal marshes to take over people's yards in some lightly developed areas, while in more densely developed areas, dikes with pumping systems or artificially elevated land is preventing the tidal inundation necessary for wetlands to encroach inland. Along the seaward boundaries, wetlands have been able to keep pace with sea level rise in some areas, while it erodes in other areas. If sea level were to rise more rapidly, however, the seaward boundary would retreat, which means that the wetlands would be eliminated in most developed areas under existing policies.

The federal regulatory wetlands program is designed to prevent the landward migration of wetlands, even if that means that they will be squeezed out of existence in developed areas. Although the program prevents people from developing on the wetlands themselves, it does not prevent them from developing the areas that would eventually be wetlands as the sea rises. Years later, when the wetlands threaten to take over the property, the regulatory program automatically issues a permit for the bulkhead that stop the wetlands from migrating inland.

Federal wildlife refuges in coastal areas generally include some dry land, so at least some wetlands will be able to migrate inland in these areas. But the program has not explicitly addressed the issue, and hence a large rise in sea level would cause a large net loss of wetlands.

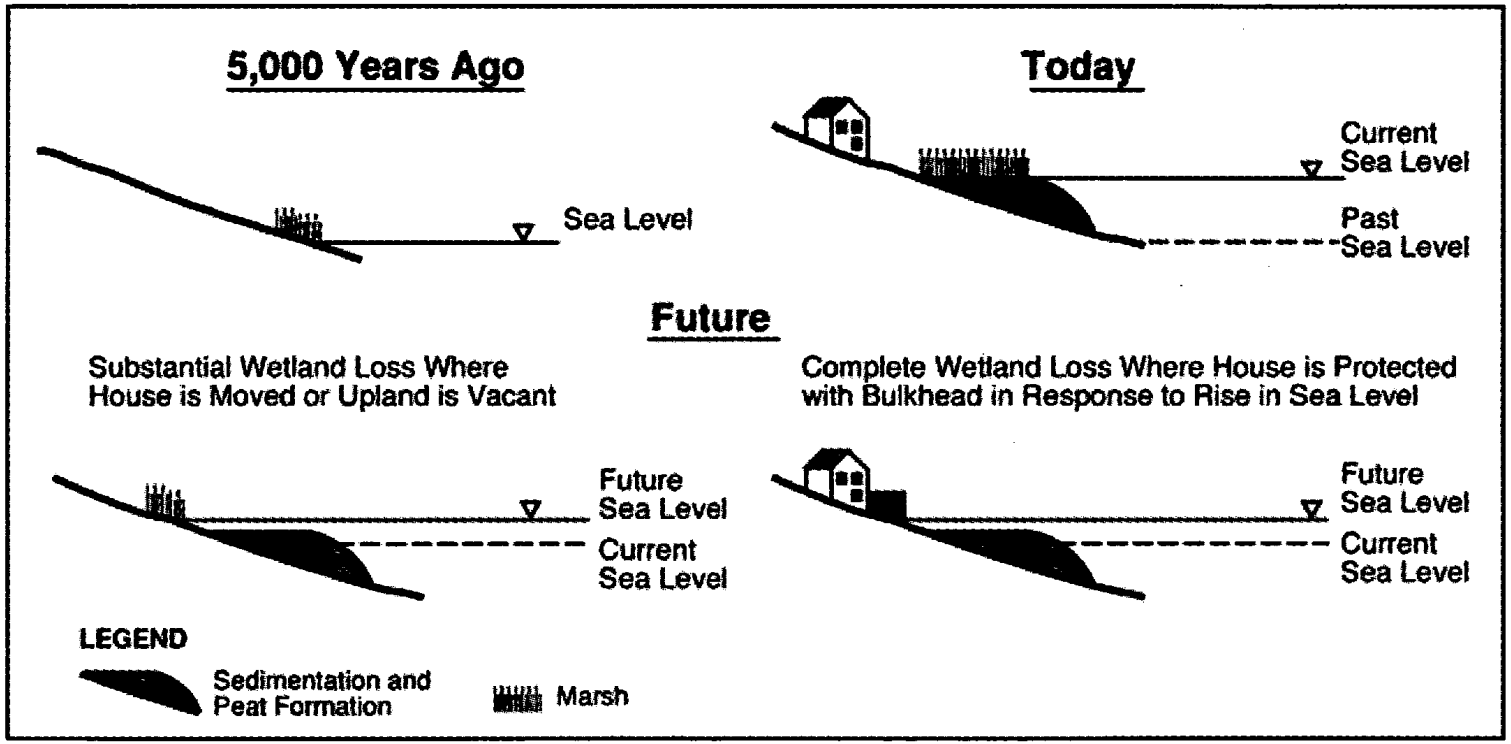
Do we really want our bay beaches and wetlands to be squeezed between development and the rising seas? If not, both Congress and the President have numerous options at their disposal:

> The Fish & Wildlife Service could purchase rolling easements to enable wetlands to migrate inland, even if nearby dry land is developed;
>
> EPA and the Corps of Engineers could modify the nationwide permit for coastal erosion structures so that it would only be automatic in areas that were developed by the year 2000, or require mitigation for the true long-term environmental impact of these structures;
>
> National Estuary Program plans could include an explicit decision regarding which areas will be protected and where wetlands and beaches will survive;
>
> Agencies that fund roads, sewage systems, and flood insurance could explicitly consider the need for wetland migration in locational decisions; and
>
> Congress could amend the Clean Water Act to require the federal regulatory wetlands program to enable wetlands in at least some areas to migrate inland, or it could amend the Coastal Zone Management Act to explicitly encourage states to develop their own plans re-

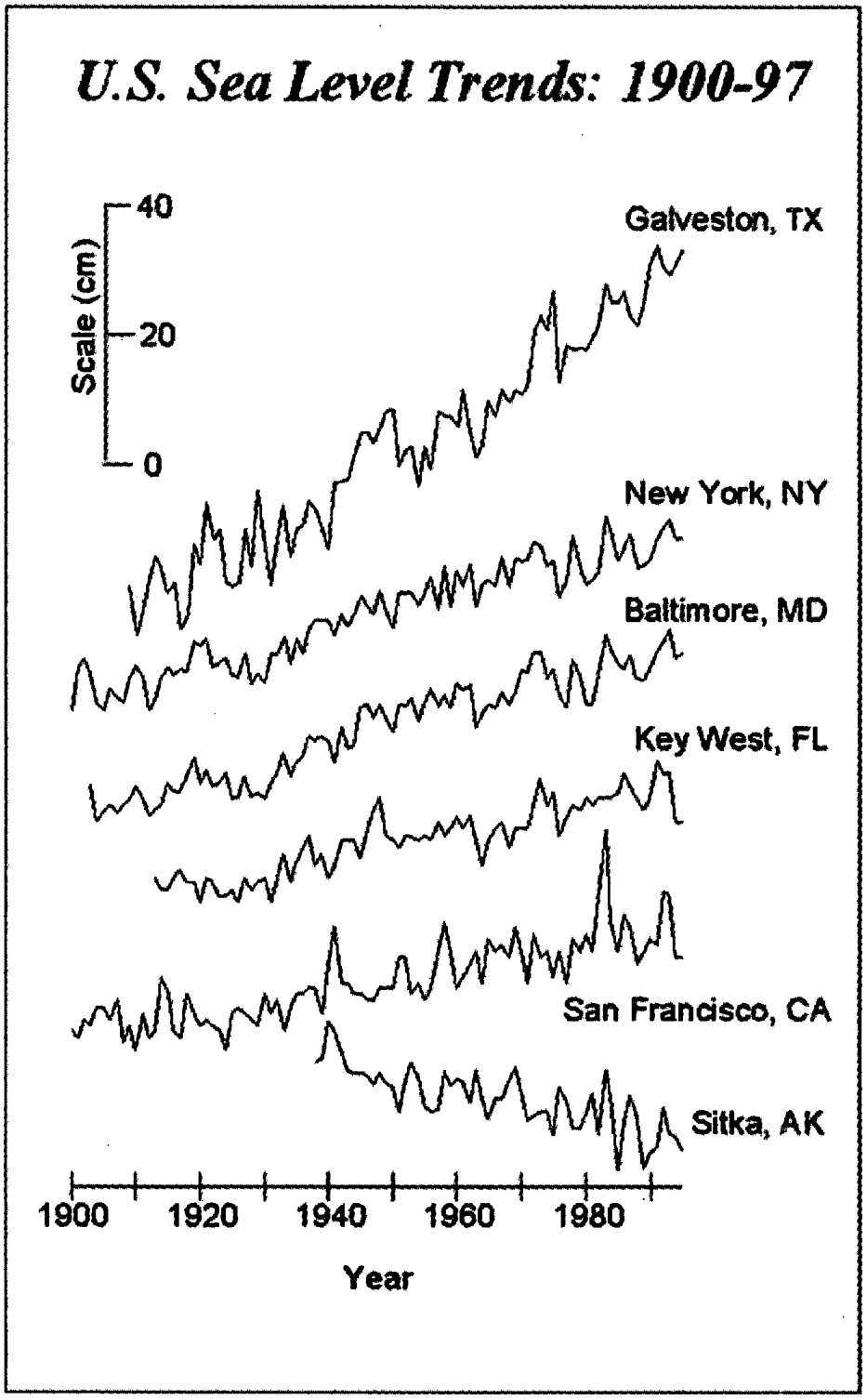
garding where wetlands will be eliminated, artificially elevated, or allowed to migrate inland.

Humanity has been adding gases to the atmosphere that are likely to warm the earth and accelerate the rate at which the sea rises. The State Department has been engaged in numerous negotiations to reduce emissions of greenhouse gases, and the President has signed a treaty that, if ratified, would require industrial nations to reduce the emissions of greenhouse gases to the 1990 level.

Apparently, the ramifications of global warming are important enough for the nation's leaders to consider a major change in how we supply our economy with energy. It makes no sense to spend tens of billions of dollars to slow global warming and do nothing to adapt to its consequences. It is time to direct the federal bureaucracy to start preparing for the consequences of global warming.

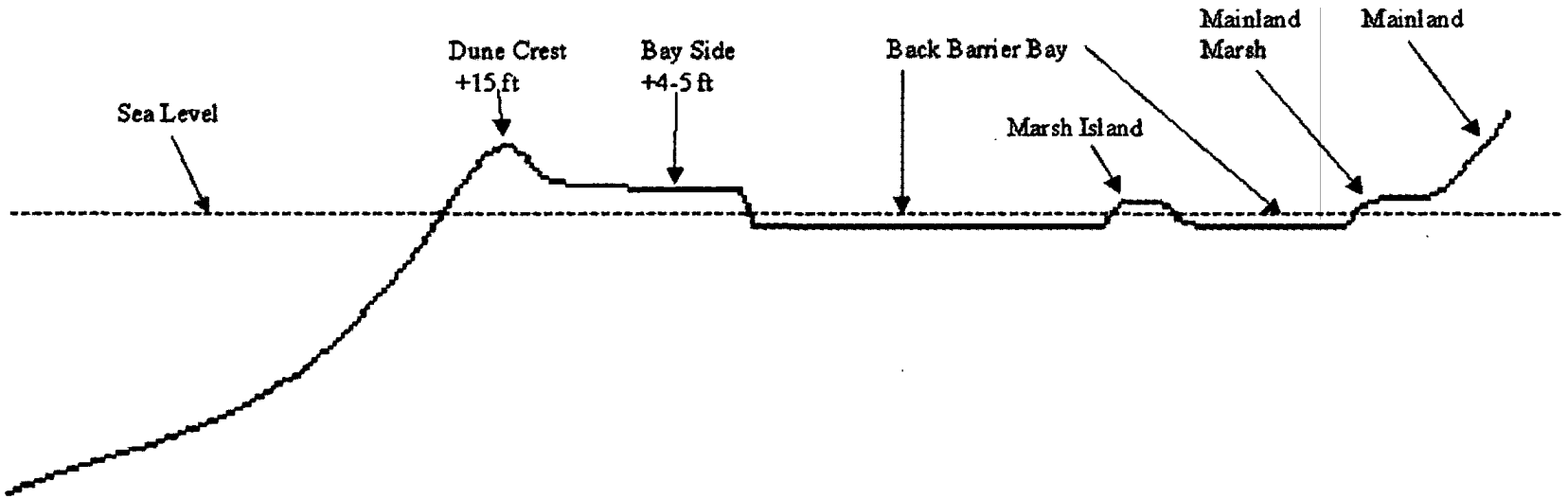

5,000 Years Ago
Sea Level
Today
Current
Sea Level
Past
Sea Level
Future
Substantial Wetland Loss Where
House is Moved or Upland is Vacant
Future
Sea Level
Current
Sea Level
Complete Wetland Loss Where House is Protected
with Bulkhead in Response to Rise in Sea Level
Future
Sea Level
Current
Sea Level
LEGEND
Sedimentation and
Peat Formation
Marsh


TODAY
Your proposal to fill the wetlands violates the Public Trust Doctrine, the Tidal Wetlands Act, and §404 of the Clean Water Act!
ABC DEVELOPERS
REJECT
ABC RIVER
BUT... THIRTY YEARS LATER
MUCH BETTER!
SOME PLAN!


U.S. Sea Level Trends: 1900-97
Scale (cm)
40
20
0
Galveston, TX
New York, NY
Baltimore, MD
Key West, FL
San Francisco, CA
Sitka, AK
1900
1920
1940
1960
1980
Year

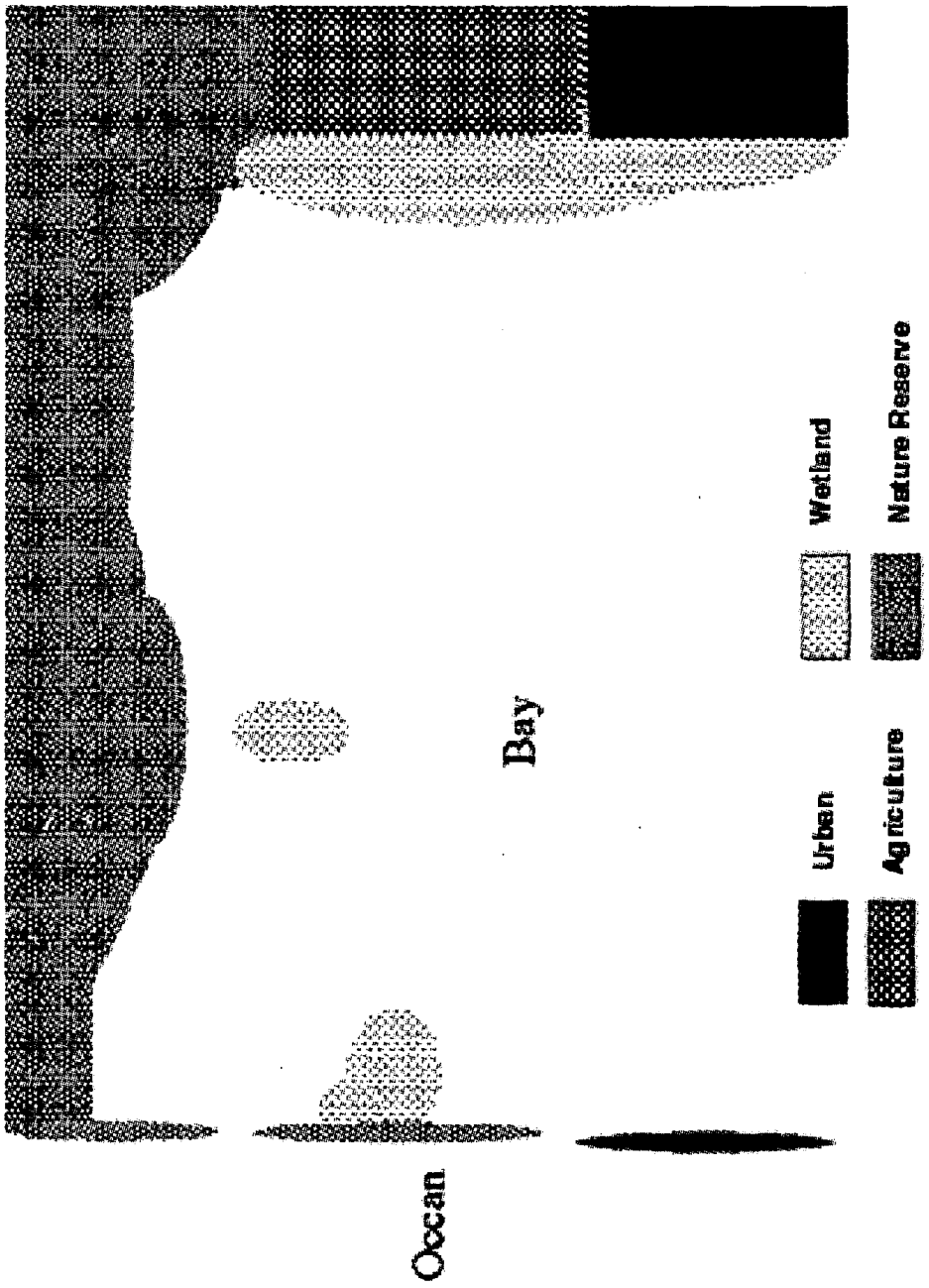
777

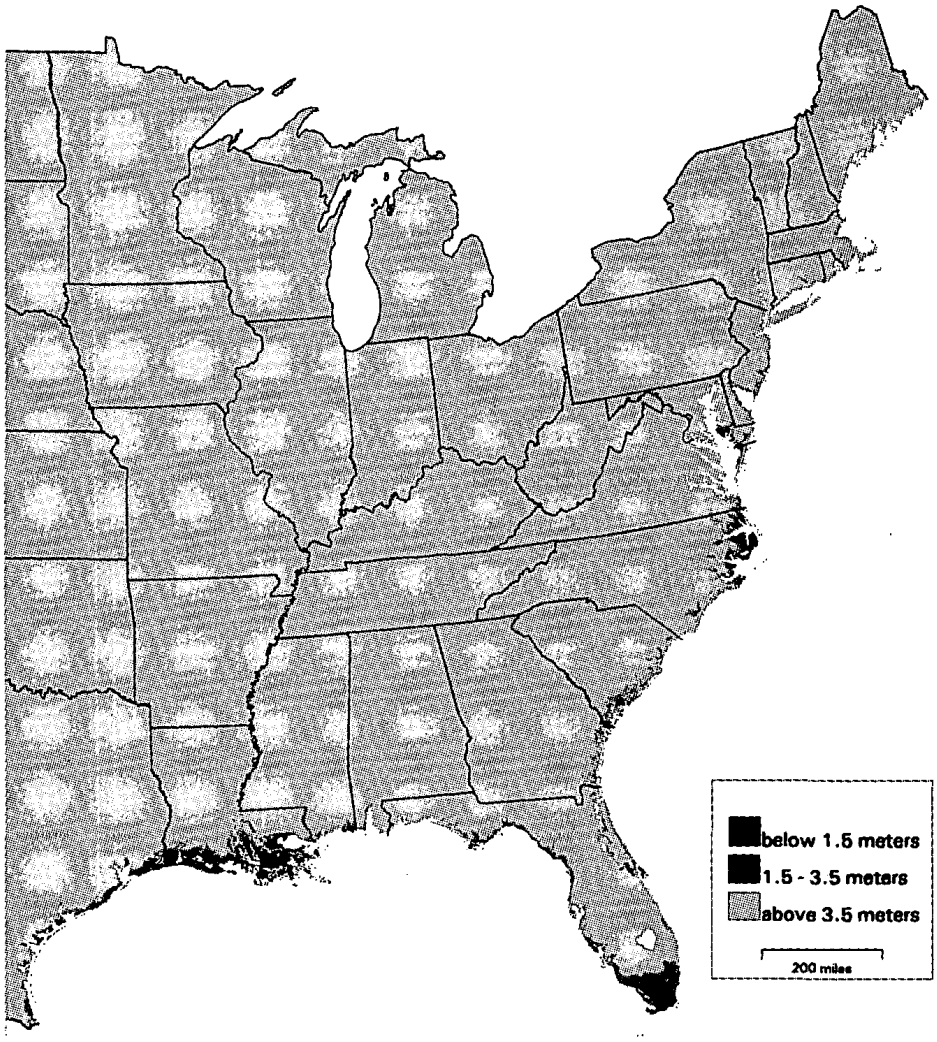
Typical Barrier Island System Profile
(Based on Long Beach Island, New Jersey)

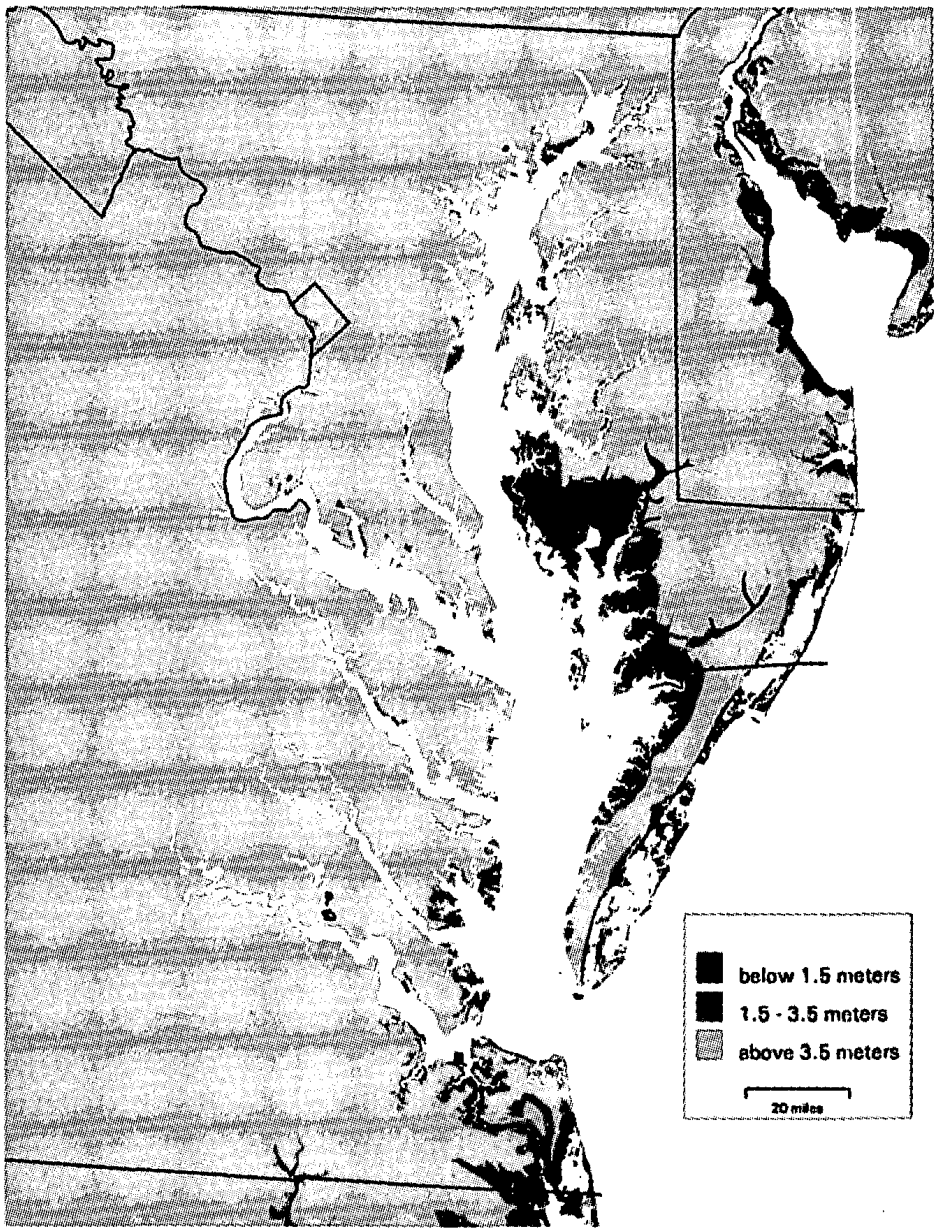


SEA RISE

2000]


Wetland
Nature Reserve
Bay
Urban
Agriculture
Ocean


below 1.5 meters
1.5 - 3.5 meters
above 3.5 meters
200 miles


below 1.5 meters
1.5 - 3.5 meters
above 3.5 meters
20 miles

Rolling Easement

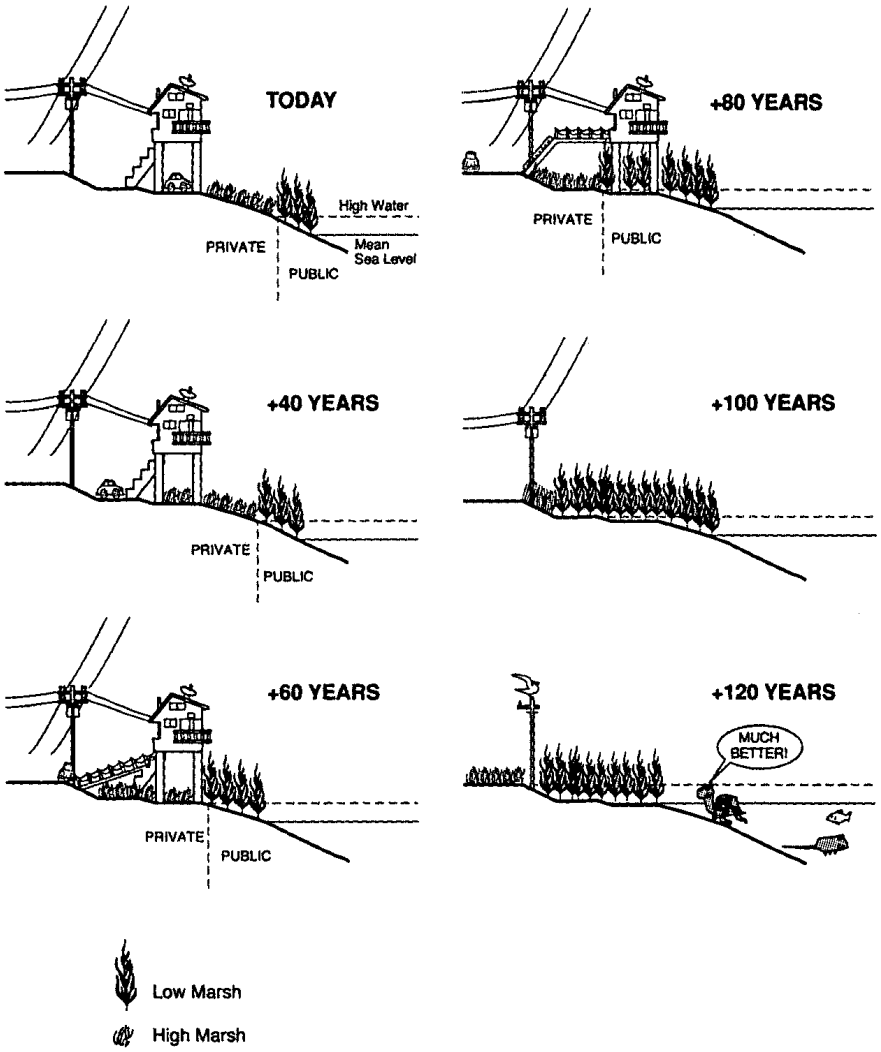


Chart 25

Notes for Table III.

[i] "No new seawalls shall be constructed in or on any sand dune system." CODE ME. R.
Ch. 355(3)(F)(1) (1996). For the purpose of these regulations, the term "seawall" includes all structures designed to prevent erosion. *See id.* at Ch 355(1)(X). Sand dune systems include any tidal shore with deposits of sand or gravel. *See* ME. REV. STAT. ANN. tit. 38, § 480-B (1) (1989). As a practical matter, that includes virtually all areas where anyone would erect shoreline armoring because rocky shores have trivial erosion, there are virtually no mud-only shores, and wetlands are generally not eroding in Maine. Along the ocean coast there has been some beach nourishment, such as Camp Ellis in 1996, and the periodic use of dredge material. Beach nourishment that generally occurs in Maine consists of the beneficial use of dredge material; but the bays have not been nourished. Indeed, the state's desire to avoid having to nourish its long shoreline was a primary motivation of the Dune Rules restricting coastal structures. *See* CODE ME. REG. Ch. 355(3)(preamble)(explaining that because sea level is rising and may accelerate, the only way to keep the beaches in areas with structures on the beach would be to spend increasing sums of money on beach nourishment).

[ii] Revetments are allowed if soft solutions are impractical. Bulkheads and other vertical walls are not allowed unless there is too little room for a revetment to be practical. Shoreline stabilization must be by the least intrusive means practical.

[iii] Beach nourishment is the preferred management strategy for dealing with coastal erosion. Telephone Interview with Rebecca Lacey, Massachusetts Coastal Zone Management Program (Nov. 10, 1999). The regulations explicitly allow beach nourishment. *See* MASS. REGS. CODE tit. 310,
§ 10.27(5) (2000).

[iv] *See* MASS. REGS. CODE tit. 310, § 10.28(3)(a) (prohibiting any structures on a dune that prevent the waves from removing sand from the dune) *and* § 10.28(3)(d) (prohibiting structures that prevent the dune from migrating landward or along the shore).

[v] *See* MASS. REGS. CODE tit. 310, § 10.30(3). (prohibiting new coastal protection structures on coastal banks for houses built before August 10, 1978). Banks refer to the face of any elevated landform-- other than a coastal dune-- along a beach, wetland, or tidal waterway. *See id.* at § 10.30(2). The prohibition's justification is that protection of one property will decrease the sediment supply along the shore and cause erosion elsewhere. *See id.* at § 10.30(1). There might be a loophole in this regulation because the regulations appear to allow structures to be built 100 or more feet landward of the top of a bank. *See id.* at § 10.30(4). If the shore later erodes and leaves that structure along the shore, the reconstruction might not be viewed as a "new" structure.

The Cape Cod Planning Commission has issued guidelines that go even farther to protect coastal resources from retreating shores. Access along the shore is retained when revetments are constructed. *See, e.g.,* CAPE COD COMMISSION, FINAL CAPE COD REGIONAL POLICY PLAN, Policy 2.2.1.7 (last modified Oct. 23, 2000) <http://www.capecodcommission.org/rpp/coastal.htm> ("Coastal engineering structures should be designed so as to allow the public to pass along the shore (either above or below the structure) in the exercise of its public trust rights to fishing, fowling and navigation"). *See also id.* .at 2.2.2.8 ("Within the 10 year floodplain no activity shall impede the landward migration of other resource areas within this area of the floodplain. Relative sea level rise and the landward migration of resource areas in response to relative sea level rise shall be incorporated into the design, construction, and location of structures and other activities proposed.")

[vi] New additional shoreline armoring is allowed along the ocean shore of Rhode Island. *See* Rhode Island Coastal Resources Management Program § 300.7(D)(1) (1993). Along some bay shores, armoring is allowed as a last resort. *See id.* at § 300.7(D)(1). In a number of areas, however, armoring is prevented to that wetlands can migrate as sea level rises. *See id.* at § 210(B)(4) ("Bulkheading and filling along the inland perimeter of a marsh prevents inland migration of wetland vegetation as sea level rises.") *See also id.* at § 210.3(C)(3) ("In Type 1 waters, structural shoreline protection may be permitted only when the primary purpose is to enhance the site as a conservation area and/or a natural buffer against storms.") Beach nourishment projects have been occurring along the ocean, but not the bay. Telephone Interview with Jeff Willis, Coastal Resources Management Council (November 12, 1999).

[vii] The Connecticut Coastal Act guarantees that "[s]tructural solutions are permissible when necessary and unavoidable for the protection of infrastructural facilities, water-dependent uses, or existing inhabited structures." CONN. GEN. STAT. § 22a-92(b)(2)(J) (1995). The statute does not distinguish between Long Island Sound and other coastal waters, as long as the salinity concentration is at least 500 parts per million. *See id.* at § 22a-93(5). A few beach nourishment projects have taken place along Long Island Sound, but there have been no projects along any of the embayments. Telephone Interview with Tom Oullette, Connecticut Department of the Environment (Oct. 14, 1999).

[viii] Extensive beach nourishment has taken place along the ocean shores. Telephone Interview with Fred Anders, New York Department of State, Division of Coastal Resources (Nov. 15, 1999.) A few projects have also taken place along bay shores, including Orchard Beach (Bronx), Rye Beach (Westchester), Asharoken (Long Island), and the state park in Smithtwown. *See id.* The Coastal Erosion Management Regulations allow shoreline armoring along both ocean and bay, but an owner must first demonstrate that non-structural measures would be ineffective. *See* N.Y. COMP. CODES R. & REGS. tit. 6, § 505.9 (2000).

[ix] New Jersey has allocated $15 million per year for beach nourishment projects along the ocean coast, and some local governments are supplementing the state allocation. Telephone Interview with Mark Mauriello, New Jersey Department of Environmental Regulation (Nov. 17, 1999). Only a few beach nourishment projects have taken place along Delaware Bay and Raritan Bay. Because NJ has been developed for so long, armoring is allowed along both ocean and bay shores, but beach nourishment makes additional armoring along the ocean unlikely in most locations. *See* N.J. ADMIN. CODE tit. 7, § 7E-3.19(b)(2) (2000).

[x] Twelve communities along Delaware Bay, and virtually the entire developed portion of Delaware's Atlantic Coast, have received beach nourishment. Telephone Interview with Robert Henry, Delware Department of Natural Resurces and Environmental Control (Nov. 17, 1999).

[xi] Virginia has no restrictions on shoreline armoring. Virginia Beach (ocean), Hampton (Buckrowe Beach and Norfolk), and Gradview Beach have all been nourished. Telephone Interview with Tony Watkinson, Virginia Marine Resources Commission (Oct. 14, 1999).

[xii] Along bays, Beach nourishment is permitted but discouraged under the Coastal Commission Guidelines. *See* N.C. ADMIN. CODE tit. 15A, r. 7H.0208(8) (Jul. 2000). There are no state projects underway, but there may be small private operations. Telephone Interview with Steve Benton, North Carolina Department of Environment and Natural Resources (Nov. 10, 1999). Beach nourishment is common along the ocean. *See id.* Shoreline armoring is prohibited along the ocean, but allowed along

Pamlico, Albemarle, and other Sounds. *See* N.C. ADMIN. CODE tit. 15A, r. 7H.0208 (a)(1)(B), (7)(D) (Jul. 2000).

[xiii] Shoreline armoring along the ocean is prohibited except to protect public highways. (a) No new erosion control structures or devices are allowed seaward of the setback line except to protect public highways built before 1990. *See* S.C. CODE ANN. § 48-39-290(B)(2)(a) (1976). Moreover, even "[e]rosion control structures or devices which existed on the effective date of this act [1990] must not be repaired or replaced if destroyed. *See id.* § 48-39-290(B)(2)(b). Along other shores, revetments are allowed; but bulkheads are generally discouraged. *See* 30 S.C. CODE ANN. REGS. 12(C) (2000). Approximately 40 miles of the state's 180 miles of ocean coast have been nourished. Telephone Interview with Bill Eiser, South Carolina Office of Ocean and Coastal Resources Management (Nov. 10, 1999). No bay shores have been nourished. *See id.*

[xiv] The statute appears to make no distinction between ocean and bay beaches: "A permit for shoreline engineering activity or for a land alteration on beaches, sand dunes, and submerged lands may be issued...[i]n the event that shoreline stabilization is necessary, either low-sloping porous rock structures or other techniques which maximize the dissipation of wave energy and minimize shoreline erosion shall be used. Permits may be granted for shoreline stabilization activities when the applicant has demonstrated that no reasonable or viable alternative exists; provided, however, that beach restoration and renourishment techniques are preferable to the construction of shoreline stabilization activities." GA. CODE ANN. § 12-5-239(c)(3)(C) (1981). However, virtually all bay shores are considered to be vegetated wetlands or mudflats, rather than beaches. Telephone Interview with Steward Stevens, Georgia Department of Natural Resources (Nov. 12, 1999). About seven miles of oceanfront shores have been nourished, but bays shores have not been nourished. *See id.*

[xv] Along the ocean, armoring is only allowed for structures that are vulnerable to erosion and built prior to the inception of the permitting program. Telephone Interview with Payden Woodruff, Florida Bureau of Beaches and Coastal Systems (Nov. 17, 1999). The state is guaranteeing $30 million per year for beach nourishment along the Atlantic and Gulf Coasts. *Id.* State law prohibits vertical sea walls along bay shores in marine and brackish environments unless rip rap is placed in front of it so that it is no longer a vertical structure. Telephone Interview with Geoffery Rabinowitz, Florida Department of Environmental Protection (Nov. 23, 1999). Bayside beach nourishment is rare.

[xvi] Alabama prohibits the use of hard structures along the Gulf, unless a variance is obtained showing non-structural alternatives are not feasible. *See* ALA. ADMIN. CODE r.335-8-2.06 (2000). Along bay shores, Alabama has no restrictions other than the federal restrictions. Telephone Interview with Gil Gilder, Coastal Programs Office Alabama Dept. of Economic and Community Affairs (Nov. 15, 1999). Beach nourishment is employed along the oceans, but rarely if ever along bays. *Id.*

[xvii] Beach nourishment is common along Mississippi Bay beaches. *See* U.S. ARMY CORPS OF ENGINEERS SHORELINE PROTECTION AND BEACH EROSION CONTROL STUDY, PHASE I: COST COMPARISON OF SHORELINE PROTECTION PROJECTS OF THE U.S. ARMY CORPS OF ENGINEERS 43 (1994) (showing that Corps of Engineers projects have placed 5.7 million cubic yards of sand along Mississippi shores). *See also Laura S. Howorth & Sondra Simpson, Sea Level Rise: Policy Implications for the Mississippi Coast, in* LONG TERM IMPLICATIONS OF SEA LEVEL CHANGE FOR THE MISSISSIPPI AND ALABAMA COASTLINES 18, 20 (David D. Burrage ed., 1990) (noting that most of Mississippi's beaches are "man-made"). Although Mississippi's Gulf Coast is entirely undeveloped, with the beach resorts entirely along the large coastal bays, the undeveloped West Ship Island has been fortified with a beach nourishment project. The Gulf Coast is undeveloped, so shoreline armoring has not been necessary, but armoring is com-

monplace along the some portions of the developed bay coasts. Telephone Interview with Howard Ladner, Mississippi Dept. Marine Resources (Nov. 15, 1999).

[xviii] Louisiana has no policy on shoreline armoring. Telephone Interview with Terry Howie, Louisiana Department of Natural Resources (Nov. 16, 1999). Grand Isle, the only resort along the Gulf, has been nourished, and the undeveloped Isles Dernieres have been fortified to ensure that they do not break up. *Id.*

[xix] The Texas Open Beaches Act declares that the public has unrestricted access to the public beach from mean low water to the vegetation line in those areas along the Gulf of Mexico where it has acquired a right of use by prescription, easement, or continuous use. *See* TEX. NAT. RES. CODE ANN. § 61.011(a) (1978). The Attorney General and the Land Office are required to "strictly and vigorously enforce the prohibition against encroachments on and interferences with the public beach easement." *Id.* § 61.011(c). The General Land Office has promulgated rules carrying out this statutory mandate: "Local governments shall not issue a permit or certificate allowing construction of an erosion response structure." 31 TEX. ADMIN. CODE § 15.6 (c)(2000). Existing erosion control structures that are on the public beach cannot be repaired. Structures within 200 feet landward of the vegetation line cannot even be repaired after a storm unless either they are protecting public structures and infrastructure, or—in the case of an erosion control structure that only protects private property—they are needed because other erosion control structures channel floodwater in their direction. *See id.* at §§ 15..6(d)(1), 15.6(d)(2). *See also id.* at §§ 15.1, 15.10(d) (identifying the geographic scope of the Dune Rules as the shores along the Gulf of Mexico other than certain areas that are not considered to be public beaches). The state had no restrictions of hard structures along other shores. Telephone Interview with Wayne Kuley, Texas General Land Office (Nov. 17, 1999). Numerous projects have been undertaken along developed parts of the Gulf of Mexico, including restoration of a beach in front of the Galveston Seawall. Telephone Interview with Bill Worsham, Texas General Land Office (Nov. 17, 1999). Along bays, beach nourishment has occurred at Port O'Connor and Corpus Cristi as a result of programs promoting the beneficial use of dredge. *See id.*

[xx] State law explicitly guarantees the right to hold back the sea along the ocean. "Revetments, breakwaters, groins, harbor channels, seawalls, cliff retaining walls, and other such construction that alters natural shoreline processes shall be permitted when required to serve coastal-dependent uses or to protect existing structures or public beaches in danger from erosion and when designed to eliminate or mitigate adverse impacts on local shoreline sand supply." California Coastal Act, CAL. PUB. RES. CODE § 30235 (West 1996). That provision applies to ocean and bays other than San Francisco Bay. *See id.* at § 30103 (excluding San Francisco Bay from the definition of coastal zone or purposes of the California Coastal Act). The Bay Area Conservation and Development Commission's authorizing legislation was designed to slow the rate at which the bay was filled. Although the wording of the statute clearly contemplates maintenance of the existing shoreline, the motivation was to stop people from converting parts of the bay to dry land. *See* CAL. GOV'T CODE §§ 66601, 66604 (West 1997). Shoreline armoring is generally allowed under the San Francisco Bay Plan, Protection of the Shoreline, Policies 1 and 4. The statute encourages dredge material to be used for beach nourishment. *See* CAL. PUB. RES. CODE § 30233(b) (West 2000). Numerous projects have been undertaken. Telephone Interview with Leslie Ewing, California Coastal Commission (Nov. 22, 1999). Beaches along San Francisco Bay have not been nourished. Telephone Interview with Art Duffy, San Francisco Bay Area Conservation Development Commission (Nov. 10, 1999).

[xxi] Along the ocean, homes built before 1977 can be protected with hard structures as a last resort. Homes built after 1978, however, are denied permits and several along the South Coast of Curry County have fallen into the water as a result. Telephone

Interviews with Paul Klarin, Oregon Coastal Management Program (Nov. 1999). At Oceanside, an expensive development called "The Capes" has been denied permit and the demise of the oceanfront row of structures is imminent. *Id.* Although the state has no beach nourishment program, the federal government has occasionally used beach nourishment on federal property or to mitigate erosion caused by navigation jetties. *Id.*

[xxii] Legislative findings indicate an aspiration to maintain natural shorelines. *See* WASH. REV. CODE § 90.58.020 (1992) Nevertheless, the statute requires local master programs to issue standards for construction of bulkheads. *See id.* at §90.58.100(6). Although the statute does not distinguish ocean and bay shorelines, it does authorize local governments to impose stricter standards for homes built after 1992. *See id.* Currently, some of the local programs are ambiguous about whether armoring the ocean shore will be allowed. Telephone Interview with Doug Canning, Washington Department of Ecology (Oct. 19, 1999). There has been relatively little armoring because most of the Washington coast has been accreting rather than eroding. *Id.* Although there has been no beach nourishment of the ocean beaches, some small projects have added sand or pebbles to shores along Puget Sound. Telephone Interview with Hugh Shipman, Washington Department of Ecology (Oct. 19, 1999).

[xxiii] Telephone Interview with Julie Penn, Alaska Coastal Management Program, Office of the Governor (Nov. 10, 1999).

[xxiv] The statute is somewhat vague on the question of shoreline armoring. *See, e.g.,* HAW. REV. STAT. § 205A-2(b)(9) (1977) (listing the protection of public beaches as an objective of coastal zone management). The Hawaii Coastal Zone Management Program interprets the statute as encouraging the use of soft over hard engineering structures, but not actually prohibiting structures. Telephone Interview with John Nakagawa, Planner, Hawaii Coastal Zone Management Program (Nov. 23, 1999). Along the ocean, beach nourishment projects have taken place at Waikiki Beach, Honokawai Beach on Maui, and Lanikai on Oahu. Telephone Interview with Sam Lemmo (Nov. 23, 1999). Bay beaches have not, however, been nourished. Telephone Interview with John Nakagawa *supra*.